JEE Main 2014 Paper 2 (B.Arch/B.Plan) Apr 6 Single sitting (Offline) Question Paper with Solutions PDF

Question Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)

Time Allowed: 3 Hours **Maximum Marks: 390**

General Instructions

(i) This paper is Paper 2 (B.Arch/B.Plan.) of JEE (Main) 2014, Annual (offline), conducted by the Central Board of Secondary Education (CBSE) in pen and paper mode on 6 April 2014, Single sitting. 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: 390.

(iii) Each multiple choice question (MCQ) has four options, of which only one is correct.

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

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

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

Mathematics (120 marks)

1. Let N be the set of natural numbers and for $\mathrm{a} \in \mathrm{N}$, aN denotes the set $\{\mathrm{a}x : x \in \mathrm{N}\}$.

If $\mathrm{bN} \cap \mathrm{cN} = \mathrm{dN}$, where b, c, d are natural numbers greater than 1 and the greatest common divisor of b and c is 1, then d equals : [4 marks]

(A) $\max\{\mathrm{b}, \mathrm{c}\}$

(B) $\min\{\mathrm{b}, \mathrm{c}\}$

(C) bc

(D) $\mathrm{b} + \mathrm{c}$

Correct Answer: (C) bc

Solution:

Concept:

- The set $a\mathrm{N}$ consists of the positive multiples of a. An intersection contains exactly the numbers that belong to both sets.
- The common positive multiples of b and c are the multiples of $\mathrm{lcm}(b, c)$, and $\gcd(b, c)\,\mathrm{lcm}(b, c) = bc$.

Step 1: Identify the least element of the intersection An integer belongs to $b\mathrm{N} \cap c\mathrm{N}$ precisely when it is divisible by both b and c. Its least positive member is therefore $\mathrm{lcm}(b, c)$. On the other hand, the least positive element of $d\mathrm{N}$ is d itself. Equality of the two sets forces equality of these least elements, so $d = \mathrm{lcm}(b, c)$. This uses the entire set condition rather than selecting an arbitrary common multiple.

Step 2: Apply the coprimality condition The given greatest common divisor is one. Thus the standard product identity gives

$$d = \mathrm{lcm}(b, c) = \frac{bc}{\gcd(b, c)} = bc.$$

Conversely, because b and c are coprime, any number divisible by both is divisible by their product, and every multiple of bc belongs to both sets. This verifies the set equality in both directions. Since $b, c > 1$, their product exceeds either individual number, excluding the maximum and minimum choices. Their sum need not be divisible by both: the coprime example $b = 2, c = 3$ gives sum five but least common multiple six.

Step 3: Conclusion The required value is $\boxed{d = bc}$. Hence, the correct option is (C).

Quick Tip to Solve: For intersections of sets of positive multiples, take the least common multiple; use the product only after checking coprimality.

2. If z is a complex number of unit modulus and argument θ, then the real part of $\frac{z(1-\bar{z})}{\bar{z}(1+z)}$ is : [4 marks]

(A) $1+\cos\frac{\theta}{2}$

(B) $1-\sin\frac{\theta}{2}$

(C) $-2\sin^2\frac{\theta}{2}$

(D) $2\cos^2\frac{\theta}{2}$

Correct Answer: (C) $-2\sin^2\frac{\theta}{2}$

Solution:

Concept:

- For a complex number of unit modulus, $z\bar{z}=1$, so $\bar{z}=z^{-1}$ and $z=\cos\theta+i\sin\theta$.
- The half-angle identity $(z-1)/(z+1)=i\tan(\theta/2)$ holds on the unit circle wherever $z\neq -1$. The original expression is undefined at $z=-1$.

Step 1: Simplify using the unit modulus Write the expression as E. Since $z\neq 0$, substitution of $\bar{z}=1/z$ is legitimate:

$$E=\frac{z(1-1/z)}{(1/z)(1+z)}=\frac{z(z-1)}{z+1}.$$

The denominator requires $z\neq -1$, which is already necessary in the printed expression. Factor $e^{i\theta/2}$ from $e^{i\theta}-1$ and $e^{i\theta}+1$. Their ratio becomes $i\tan(\theta/2)$; hence $E=iz\tan(\theta/2)$.

Step 2: Extract and simplify the real part Insert $z=\cos\theta+i\sin\theta$:

$$E=(-\sin\theta+i\cos\theta)\tan\frac{\theta}{2}.$$

Therefore

$$\operatorname{Re}E=-\sin\theta\tan\frac{\theta}{2}=-2\sin^2\frac{\theta}{2}.$$

The last step follows by writing $\sin\theta=2\sin(\theta/2)\cos(\theta/2)$ and cancelling the nonzero cosine on the allowed domain. As a check, $z=1$, or $\theta=0$, gives zero directly. Options (A), (B) and (D) give respectively two, one and two at this value, so none can be the required identity.

Step 3: Conclusion On the domain of the given expression, the real part is $\boxed{-2\sin^2(\theta/2)}$. Hence, the correct option is (C).

Quick Tip to Solve: On the unit circle replace the conjugate by the reciprocal first; then use the ratio of the difference and sum to expose a half-angle.

3. If the roots of the equation

$\frac{1}{x+p}+\frac{1}{x+q}=\frac{1}{r}$ **are equal in magnitude and opposite in sign, then the product of roots is :** [4 marks]

(A) (p^2+q^2)

(B) $\frac{1}{2}(p^2+q^2)$

(C) $-\frac{1}{2}(p^2+q^2)$

(D) $-\frac{1}{2}(p^2-q^2)$

Correct Answer: (C) $-\frac{1}{2}(p^2+q^2)$

Solution:

Concept:

- For a monic quadratic $x^2+Bx+C=0$, the sum of its two roots is $-B$, while their product is C.
- Roots equal in magnitude and opposite in sign have zero sum. Clearing a rational equation requires retaining its restrictions $x \neq -p, -q$ and $r \neq 0$.

Step 1: Convert the equation to a quadratic Combine the two fractions before cross-multiplying:

$$\frac{2x+p+q}{(x+p)(x+q)}=\frac{1}{r}.$$

For values for which the given equation is defined, this yields

$$(x+p)(x+q)=r(2x+p+q).$$

Expanding and collecting terms gives the monic equation

$$x^2+(p+q-2r)x+pq-r(p+q)=0.$$

The premise states that its valid roots are opposite, so their sum is zero; the linear coefficient must vanish.

Step 2: Use the zero sum to find the product The vanishing linear coefficient gives $2r=p+q$. Substitute this relation into the constant term, which is the root product:

$$\begin{aligned}\alpha\beta &= pq-\frac{(p+q)^2}{2}\\ &= pq-\frac{p^2+2pq+q^2}{2}\\ &= -\frac{p^2+q^2}{2}.\end{aligned}$$

The mixed product cancels, so the final expression is symmetric in p and q, as the original equation is. The positive choices (A) and (B) have the wrong sign for opposite real roots. Choice (D) has a difference of squares instead of the required symmetric sum and does not result from the constant term. The conclusion is conditional on the stated valid roots; excluded poles are never counted as roots.

Step 3: Conclusion The product of the roots is $\boxed{-\frac{1}{2}(p^2+q^2)}$. Hence, the correct option is (C).

Quick Tip to Solve: When a rational equation has opposite roots, first clear denominators and set the quadratic linear coefficient to zero before using the constant term.

4. If $S_k = \begin{pmatrix} 1 & k \\ 0 & 1 \end{pmatrix}$, $k \in \mathrm{N}$, where N is the set of natural numbers, then $(\mathrm{S}_2)^{\mathrm{n}}(\mathrm{S}_{\mathrm{k}})^{-1}$, for $\mathrm{n} \in \mathrm{N}$, is : [4 marks]

(A) S_{2n+k-1}

(B) S_{2^n+k-1}

(C) S_{2^n-k}

(D) S_{2n-k}

Correct Answer: (D) S_{2n-k}

Solution:

Concept:

- For the shear matrix $S_t = \begin{pmatrix} 1 & t \\ 0 & 1 \end{pmatrix}$, multiplying two such matrices adds their upper-right entries.
- The identity matrix is S_0. The inverse is obtained by changing the sign of the upper-right entry, since $S_t S_{-t} = I$.

Step 1: Establish the multiplication and power rules Direct multiplication gives

$$\begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & b \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & a+b \\ 0 & 1 \end{pmatrix}.$$

Thus the parameters add, even though the matrices themselves are being multiplied. Repeated application to n factors of S_2 gives $(S_2)^n = \begin{pmatrix} 1 & 2n \\ 0 & 1 \end{pmatrix}$. The entry is $2n$, not 2^n, because each new factor contributes another two to the upper-right entry; the diagonal entries remain one.

Step 2: Multiply by the inverse The determinant of S_k is one, so the inverse exists and is $(S_k)^{-1} = \begin{pmatrix} 1 & -k \\ 0 & 1 \end{pmatrix}$. Consequently,

$$(S_2)^n (S_k)^{-1} = \begin{pmatrix} 1 & 2n-k \\ 0 & 1 \end{pmatrix} = S_{2n-k}.$$

This is the intended matrix formula for the indicated parameter. If $2n-k$ is zero or negative, the displayed matrix is still perfectly well defined; the same algebraic notation extends the defining formula to that parameter. For example, $n = 2, k = 1$ gives upper-right entry three, immediately excluding the exponential and added-index expressions. There is no extra subtraction of one: that would change an entry that direct multiplication fixes exactly.

Step 3: Conclusion The resulting matrix is $\boxed{\begin{pmatrix} 1 & 2n-k \\ 0 & 1 \end{pmatrix}}$, denoted S_{2n-k} by the same formula. Hence, the correct option is (D).

Quick Tip to Solve: For upper triangular matrices with unit diagonal and one off-diagonal entry, track the off-diagonal parameter additively; inversion negates it.

5. In a ΔABC, if $\begin{vmatrix} 1 & a & b \\ 1 & c & a \\ 1 & b & c \end{vmatrix} = 0$, **then** $\sin^2 A + \sin^2 B + \sin^2 C$ **is :** [4 marks]

(A) $\frac{9}{4}$

(B) $\frac{5}{4}$

(C) 2

(D) $\frac{3\sqrt{3}}{2}$

Correct Answer: (A) $\frac{9}{4}$

Solution:

Concept:

- Expanding a determinant along a convenient row converts the condition into an algebraic relation between the triangle side lengths a, b, c.
- For real side lengths, a sum of nonnegative squares can vanish only when each square vanishes. Equal sides imply equal angles in a triangle.

Step 1: Expand and rearrange the determinant Expanding along the first row gives

$$0 = (c^2 - ab) - a(c - a) + b(b - c).$$

Collecting terms, the determinant condition is

$$a^2 + b^2 + c^2 - ab - bc - ca = 0.$$

The same expression can be written as

$$\frac{1}{2}\big((a - b)^2 + (b - c)^2 + (c - a)^2\big) = 0.$$

Every summand is nonnegative because the triangle side lengths are real. Therefore all three differences must be zero, and $a = b = c$. This stronger conclusion is essential; the determinant is not merely indicating an arbitrary isosceles triangle.

Step 2: Evaluate the trigonometric sum The triangle is equilateral, so the angle sum and equality of its angles give $A = B = C = 60^\circ$. Thus

$$\sin^2 A + \sin^2 B + \sin^2 C = 3\sin^2 60^\circ = 3\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{9}{4}.$$

The result is independent of the common side length, as it must be for an expression involving angles alone. The alternatives $5/4$, 2, and $3\sqrt{3}/2$ do not equal the sum of three copies of $3/4$. In particular, the final square removes the radical; retaining an unsquared $\sqrt{3}/2$ would be a trigonometric evaluation error.

Step 3: Conclusion The required sum is $\boxed{\frac{9}{4}}$. Hence, the correct option is (A).

Quick Tip to Solve: When a triangle determinant yields $a^2 + b^2 + c^2 - ab - bc - ca = 0$, rewrite it as half the sum of squared side differences to prove equilateralness.

6. Suppose that six students, including Madhu and Puja, are having six beds arranged in a row. Further, suppose that Madhu does not want a bed adjacent to Puja. Then the number of ways, the beds can be allotted to students is : [4 marks]

(A) 264

(B) 480

(C) 600

(D) 384

Correct Answer: (B) 480

Solution:

Concept:

- Six distinct students can be assigned bijectively to six ordered beds in $6!$ ways. Bed positions are distinguishable because they are arranged in a row.
- To count assignments avoiding adjacency, subtract adjacent assignments from the unrestricted total. A specified adjacent pair is counted as a single block, with two internal orders.

Step 1: Count all and adjacent assignments Ignoring the restriction initially, choose an ordering of the six students along the six bed positions. The number is

$$6! = 720.$$

For the unwanted assignments, join Madhu and Puja into one adjacent block. This leaves five distinguishable objects to arrange: the block and the other four students. They can be ordered in $5!$ ways. Inside the block Madhu may precede Puja or Puja may precede Madhu, providing two different assignments for each block position.

Step 2: Subtract the forbidden cases The number of assignments in which the two students occupy neighbouring beds is therefore

$$2 \times 5! = 2 \times 120 = 240.$$

Every adjacent assignment appears exactly once in this block count: its pair has a unique position and a unique internal order. Subtracting gives

$$720 - 240 = 480.$$

As a separate check, the pair of bed positions has $\binom{6}{2} = 15$ choices, of which five are adjacent. The ten nonadjacent choices admit two orders of Madhu and Puja and $4!$ assignments of the other students, giving $10 \times 2 \times 24 = 480$ again. The options 264, 600 and 384 fail this direct independent count; in particular, subtracting only $5!$ would forget one internal order of the forbidden pair.

Step 3: Conclusion The number of admissible bed allotments is $\boxed{480}$. Hence, the correct option is (B).

Quick Tip to Solve: For two specified people who must not be neighbours in a row, use $n! - 2(n-1)!$; the factor two records the two internal orders of the adjacent block.

7. Sum of the last 30 coefficients of powers of x in the binomial expansion of $(1+x)^{59}$ is : [4 marks]

(A) 2^{29}

(B) 2^{28}

(C) $2^{59} - 2^{29}$

(D) 2^{58}

Correct Answer: (D) 2^{58}

Solution:

Concept:

- The coefficient of x^r in $(1+x)^n$ is $\binom{n}{r}$, for $0 \le r \le n$.
- Binomial coefficients satisfy $\binom{n}{r} = \binom{n}{n-r}$; their sum is 2^n, obtained by substituting $x = 1$.

Step 1: Identify the coefficients included in the sum The expansion has powers from x^0 to x^{59}, so it contains 60 coefficients. Its last 30 coefficients correspond to exponents $30, 31, \ldots, 59$. Thus the required sum is

$$S = \sum_{r=30}^{59} \binom{59}{r}.$$

Counting the constant coefficient is essential: the exponent 59 gives 60 terms, not 59 terms. The complementary first half contains exactly the exponents $0, 1, \ldots, 29$.

Step 2: Pair the two halves and use the total sum For every r from 30 to 59, the integer $59 - r$ runs from 29 down to 0. Symmetry therefore gives

$$S = \sum_{r=0}^{29} \binom{59}{r}.$$

There is no unpaired central coefficient because the exponent is odd. Adding the two equal halves and applying the binomial theorem at $x = 1$,

$$2S = \sum_{r=0}^{59} \binom{59}{r} = (1+1)^{59} = 2^{59}, \qquad S = 2^{58}.$$

Options (A) and (B) incorrectly halve the exponent rather than the total coefficient sum. Option (C) subtracts 2^{29}, which is not the sum of the first 30 coefficients of this expansion.

Step 3: Conclusion The sum of the last 30 coefficients is $\boxed{2^{58}}$. Hence, the correct option is (D).

Quick Tip to Solve: For an odd binomial exponent, symmetry splits its even number of coefficients into two equal-sum halves.

8. If

$$\frac{48}{2.3}+\frac{47}{3.4}+\frac{46}{4.5}+\cdots+\frac{2}{48.49}+\frac{1}{49.50}$$

$=\frac{51}{2}+\mathrm{K}\left(1+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{50}\right)$**, then**

K **equals :** [4 marks]

(A) -1

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

(C) 1

(D) 2

Correct Answer: (A) -1

Solution:

Concept:

- Rewrite the general term using partial fractions so that consecutive denominators cancel in the sum.
- Write $H_n = 1+\frac{1}{2}+\cdots+\frac{1}{n}$. Then $H_{49} = H_{50} - \frac{1}{50}$.

Step 1: Express each summand in partial fractions The dots between consecutive denominator integers denote multiplication. With $k = 2, 3, \ldots, 49$, the numerator is $50 - k$, giving

$$S = \sum_{k=2}^{49} \frac{50-k}{k(k+1)}.$$

Write the general term as $A/k + B/(k+1)$. Equating numerators gives $(A+B)k + A = 50 - k$, so $A = 50$ and $B = -51$. Hence

$$\frac{50-k}{k(k+1)} = \frac{50}{k} - \frac{51}{k+1}.$$

The first and last terms are respectively $48/(2\cdot 3)$ and $1/(49\cdot 50)$, confirming the summation limits.

Step 2: Collect harmonic sums and compare coefficients Summing the partial fractions gives

$$\begin{aligned} S &= 50(H_{49}-1) - 51\left(H_{50} - 1 - \frac{1}{2}\right) \\ &= 50\left(H_{50} - \frac{1}{50}\right) - 50 - 51H_{50} + \frac{153}{2} \\ &= \frac{51}{2} - H_{50}. \end{aligned}$$

The given expression is $S = \frac{51}{2} + KH_{50}$. Since $H_{50} > 0$, comparing the two expressions uniquely gives $K = -1$. Option (B) has only half the required harmonic coefficient; options (C) and (D) give a positive correction, whereas the actual correction is negative.

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

Quick Tip to Solve: For $(c-k)/(k(k+1))$, use $c/k - (c+1)/(k+1)$ and check both end terms before summing.

9. $\log_{10} 2$, $\log_{10}(2^x - 1)$ **and** $\log_{10}(2^x + 3)$ **are three consecutive terms of an A. P. for :** [4 marks]

(A) no real x

(B) exactly one real x

(C) exactly two real x

(D) more than two real x.

Correct Answer: (B) exactly one real x

Solution:

Concept:

- Three real numbers u, v, w are consecutive terms of an arithmetic progression exactly when $2v = u + w$.
- Logarithm arguments must be positive. For positive arguments, $\log a + \log b = \log(ab)$, and the logarithm is one-to-one.

Step 1: Impose the domain and form the progression equation Put $t = 2^x$. The middle logarithm requires $t - 1 > 0$, so $t > 1$, equivalently $x > 0$. The other two arguments are then positive automatically. The arithmetic-progression condition is

$$2\log_{10}(t-1) = \log_{10} 2 + \log_{10}(t+3).$$

Both sides can be combined using logarithm laws because the domain has already been enforced. We obtain

$$\log_{10}(t-1)^2 = \log_{10}\big(2(t+3)\big).$$

Step 2: Solve and retain only admissible roots Equality of the positive logarithm arguments gives

$$(t-1)^2 = 2(t+3) \quad \Longrightarrow \quad t^2 - 4t - 5 = 0 \quad \Longrightarrow \quad (t-5)(t+1) = 0.$$

The root $t = -1$ is impossible because $2^x > 0$, and also violates $t > 1$. The root $t = 5$ is admissible and yields the unique value $x = \log_2 5$. Direct substitution gives arguments $2, 4, 8$, whose logarithms are $\log_{10} 2, 2\log_{10} 2, 3\log_{10} 2$, a genuine arithmetic progression. Thus there is a solution, but no second real solution; the rejected negative algebraic root cannot be counted as a value of 2^x.

Step 3: Conclusion Exactly one real value, $\boxed{x = \log_2 5}$, satisfies the condition. Hence, the correct option is (B).

Quick Tip to Solve: Substitute the positive exponential first, and impose every logarithm's domain before counting quadratic roots.

10. Let $f(x) = (x+1)^2 - 1$, $x \geq -1$, then the set $\{x : f(x) = f^{-1}(x)\}$: [4 marks]

(A) is an empty set

(B) contains exactly one element

(C) contains exactly two elements

(D) contains more than two elements.

Correct Answer: (C) contains exactly two elements

Solution:

Concept:

- On $[-1, \infty)$, the function $f(x) = (x+1)^2 - 1$ is strictly increasing and has range $[-1, \infty)$, so its inverse exists there.
- For a strictly increasing function, an intersection with its inverse must be a fixed point: otherwise a two-cycle would contradict increasing order.

Step 1: Establish the common domain and inverse Since $x + 1 \geq 0$, squaring preserves strict order on the stated domain. Solving $y = (x+1)^2 - 1$ with this restriction gives

$$x + 1 = \sqrt{y+1}, \qquad f^{-1}(y) = \sqrt{y+1} - 1, \quad y \geq -1.$$

Thus both sides of the equation in the question are defined exactly for $x \geq -1$. The positive square-root branch is required; including a negative branch would destroy the specified inverse.

Step 2: Reduce the intersection equation to fixed points Suppose $f(x) = f^{-1}(x) = y$. Applying f gives $f(y) = x$. If $y > x$, strict increase would imply $f(y) > f(x)$, that is $x > y$, a contradiction. If $y < x$, the same argument gives $x < y$, again a contradiction. Hence $y = x$, and it suffices to solve

$$f(x) = x \implies x^2 + 2x = x \implies x(x+1) = 0.$$

Both roots -1 and 0 belong to the common domain. Each is fixed by both the function and its inverse, so neither is extraneous. There are no other intersections by the increasing-order argument; this rules out the empty, single-element and more-than-two-element alternatives.

Step 3: Conclusion The required set is $\boxed{\{-1, 0\}}$, containing exactly two elements. Hence, the correct option is (C).

Quick Tip to Solve: For a strictly increasing function, solve $f(x) = x$ to locate its intersections with its inverse, then check the domain.

11. $f(x) = |x \log_e x|$, $x > 0$, **is monotonically decreasing in :** [4 marks]

(A) $\left(0, \frac{1}{e}\right)$

(B) $\left[\frac{1}{e}, 1\right]$

(C) $(1, e)$

(D) (e, ∞)

Correct Answer: (B) $\left[\frac{1}{e}, 1\right]$

Solution:

Concept:

- For $x > 0$, the sign of $x \ln x$ is the sign of $\ln x$, which changes at $x = 1$.
- On an interval of differentiability, a negative derivative implies a decreasing function. The derivative of $x \ln x$ is $1 + \ln x$.

Step 1: Remove the absolute value on each domain interval When $0 < x < 1$, the logarithm is negative, whereas for $x > 1$ it is positive. Therefore

$$f(x) = \begin{cases} -x \ln x, & 0 < x < 1, \\ x \ln x, & x \geq 1. \end{cases}$$

The values agree at $x = 1$, where $f(1) = 0$. We must differentiate these separate expressions rather than differentiate the absolute value as if its sign were constant throughout the domain.

Step 2: Determine the derivative signs and check the options On $(0, 1)$, the derivative is $f'(x) = -(1 + \ln x)$. It vanishes at $x = e^{-1}$, is positive before that point, and is negative between e^{-1} and 1. On $(1, \infty)$, the derivative is $1 + \ln x > 0$. Thus

x	$(0, e^{-1})$	$(e^{-1}, 1)$	$(1, \infty)$
sign of $f'(x)$	$+$	$-$	$+$

Continuity at e^{-1} and 1 extends the decreasing behaviour to the closed interval $[e^{-1}, 1]$; a zero derivative at the left endpoint does not invalidate monotonic decrease. Option (A) is an increasing interval, and both (C) and (D) lie in the increasing region beyond 1.

Step 3: Conclusion The function decreases on $\boxed{[1/e, 1]}$. Hence, the correct option is (B).

Quick Tip to Solve: Split an absolute-value expression where its interior changes sign, then make a derivative sign chart on each piece.

12. Let $f(x) = \begin{cases} \frac{1}{|x|} & \text{if } |x| > 2 \\ a + bx^2 & \text{if } |x| \leq 2 \end{cases}$,

then $f(x)$ is differentiable at $x = -2$ for : [4 marks]

(A) $a = \frac{3}{4}$ and $b = -\frac{1}{16}$

(B) $a = -\frac{1}{4}$ and $b = \frac{1}{16}$

(C) $a = \frac{1}{4}$ and $b = -\frac{1}{16}$

(D) $a = \frac{3}{4}$ and $b = \frac{1}{16}$

Correct Answer: (A) $a = \frac{3}{4}$ and $b = -\frac{1}{16}$

Solution:

Concept:

- Differentiability at a joining point requires continuity and equality of the left-hand and right-hand derivatives.
- For negative x, $|x| = -x$, so $1/|x| = -1/x$ and its derivative is $1/x^2$.

Step 1: Apply continuity at the joining point Near -2, the outer branch is used on the left, where $x < -2$. Since these values are negative, that branch is $-1/x$. The inner branch applies on the right and at the joining point itself. Hence

$$\lim_{x \to -2^-} f(x) = \frac{1}{2}, \qquad f(-2) = \lim_{x \to -2^+} f(x) = a + 4b.$$

Continuity, which is necessary for differentiability, therefore imposes

$$a + 4b = \frac{1}{2}.$$

Equality of branch derivatives alone would not suffice if these function values did not agree.

Step 2: Match the one-sided derivatives and solve Once continuity holds, the derivatives from the smooth branches give the corresponding one-sided derivatives at the join. On the left, differentiating $-1/x$ gives $1/x^2$, hence a slope $1/4$. On the right, differentiating $a + bx^2$ gives $2bx$, hence a slope $-4b$. Therefore

$$-4b = \frac{1}{4} \quad \Longrightarrow \quad b = -\frac{1}{16}.$$

Substituting in the continuity equation yields

$$a + 4\left(-\frac{1}{16}\right) = \frac{1}{2} \quad \Longrightarrow \quad a = \frac{3}{4}.$$

With these constants the common value is $1/2$ and the common slope is $1/4$, verifying both conditions. Options with positive b give the wrong slope sign, and the other negative-b option gives the wrong joining value.

Step 3: Conclusion Differentiability requires $\boxed{a = \frac{3}{4},\ b = -\frac{1}{16}}$. Hence, the correct option is (A).

Quick Tip to Solve: At a negative joining point, replace $|x|$ by $-x$ before differentiating, and impose continuity as a separate equation.

13. If $f(x) = (x-p)(x-q)(x-r)$, where $p < q < r$, are real numbers, then the application of Rolle's theorem on f leads to : [4 marks]

(A) $(p+q+r)^2 = 3(qr+rp+pq)$

(B) $(p+q+r)^2 > 3(qr+rp+pq)$

(C) $(p+q+r)^2 < 3(qr+rp+pq)$

(D) $(p+q+r)^2(qr+rp+pq) = 3$

Correct Answer: (B) $(p+q+r)^2 > 3(qr+rp+pq)$

Solution:

Concept:

- Rolle's theorem applies to a function continuous on a closed interval, differentiable inside it, and equal at its endpoints. It guarantees a point where the derivative vanishes.
- A quadratic with two distinct real roots has a strictly positive discriminant. For $Ax^2 + Bx + C$, this discriminant is $B^2 - 4AC$.

Step 1: Apply Rolle's theorem on the two intervals The polynomial f is continuous and differentiable everywhere. Also $f(p) = f(q) = f(r) = 0$. Applying Rolle's theorem separately on $[p, q]$ and $[q, r]$ gives points $c_1 \in (p, q)$ and $c_2 \in (q, r)$ such that $f\prime(c_1) = f\prime(c_2) = 0$. The intervals do not overlap, so these two stationary points are distinct. Strict ordering of the three roots is essential here.

Step 2: Compute the derivative and its discriminant Expanding before differentiating gives

$$f(x) = x^3 - (p+q+r)x^2 + (pq+qr+rp)x - pqr,$$

and therefore

$$f\prime(x) = 3x^2 - 2(p+q+r)x + (pq+qr+rp).$$

This quadratic has the two distinct real zeros just established, so

$$4(p+q+r)^2 - 12(pq+qr+rp) > 0.$$

Dividing by the positive number 4 preserves the inequality.

Step 3: Check the options and strictness The result is $(p+q+r)^2 > 3(pq+qr+rp)$. Equality in option (A) would make the derivative have a repeated root and contradict the two distinct Rolle points. Option (C) would give a negative discriminant and no real stationary points. The product equation in (D) does not follow from the theorem. An algebraic check is

$$(p+q+r)^2 - 3(pq+qr+rp) = \tfrac{1}{2}\left[(p-q)^2 + (q-r)^2 + (r-p)^2\right] > 0,$$

in agreement with the calculus argument.

Step 4: Conclusion $(p+q+r)^2 > 3(qr+rp+pq)$. Hence, the correct option is (B).

Quick Tip to Solve: For a cubic with three distinct real zeros, use Rolle's theorem twice: its quadratic derivative must have a positive, rather than zero, discriminant.

14. Let $f(x) = |x - x_1| + |x - x_2|$, where x_1 and x_2 are distinct real numbers. Then the number of points at which $f(x)$ is minimum, is : [4 marks]

(A) 1

(B) 2

(C) 3

(D) more than 3

Correct Answer: (D) more than 3

Solution:

Concept:

- The value $|x - a|$ is the distance from x to a on the real line. The sum of the distances to two fixed points is at least the distance between those points.
- Absolute-value expressions can be evaluated piecewise after ordering the fixed points. A constant value throughout an interval yields infinitely many minimizers.

Step 1: Order the two fixed points Let $a = \min(x_1, x_2)$ and $b = \max(x_1, x_2)$. Distinctness gives $a < b$, and the expression is unchanged when the two terms are exchanged. We therefore study $f(x) = |x - a| + |x - b|$. This ordering avoids assuming an ordering that the question has not stated.

Step 2: Evaluate the function in all three regions For $x < a$, both distances point to the right, so

$$f(x) = (a - x) + (b - x) = a + b - 2x.$$

This decreases as x approaches a. For every $x \in [a, b]$,

$$f(x) = (x - a) + (b - x) = b - a.$$

For $x > b$, both distances point to the left and

$$f(x) = (x - a) + (x - b) = 2x - a - b,$$

which increases as x moves to the right. Thus neither exterior region can produce a smaller value than $b - a$.

Step 3: Count the minimizing points The whole closed interval $[a, b]$, including both endpoints and every interior point, attains the same least value $b - a$. Since its length is positive, it contains infinitely many real points. In particular, selecting any four different points in this interval already rules out the finite counts 1, 2 and 3 listed in the other options. The endpoints alone are not the full set of minimizers; the straight segment between them also gives equality in the distance inequality.

Step 4: Conclusion The minimum occurs at every point between x_1 and x_2, so there are infinitely many such points, which is more than 3. Hence, the correct option is (D).

Quick Tip to Solve: For the sum of distances to two points on a line, test the entire interval joining them before counting only stationary points or endpoints.

15. If $\int \frac{1-5\sin^2 x}{\cos^5 x \sin^2 x}dx = \frac{f(x)}{\cos^5 x} + C$, then $f(x)$ is : [4 marks]

(A) $-\operatorname{cosec} x$

(B) $\operatorname{cosec} x$

(C) $\cot x$

(D) $-\cot x$

Correct Answer: (D) $-\cot x$

Solution:

Concept:

- An indefinite-integral identity can be verified by differentiating the proposed antiderivative. Its domain excludes zeros of every sine or cosine in a denominator.
- For products of reciprocal trigonometric powers, combine the product-rule terms over a common denominator and use $\cos^2 x + \sin^2 x = 1$.

Step 1: Rewrite the most promising candidate The proposed antiderivative has the form $f(x)\sec^5 x$. Testing option (D), $f(x) = -\cot x$, simplifies that expression to

$$F(x) = -\frac{\cot x}{\cos^5 x} = -\frac{1}{\sin x \cos^4 x}.$$

This simplification is useful because its derivative will have the required denominator $\sin^2 x \cos^5 x$. Work on any interval where $\sin x \cos x \neq 0$, so every expression is defined.

Step 2: Differentiate and compare exactly Using $F(x) = -(\sin x)^{-1}(\cos x)^{-4}$, the product and chain rules give

$$\begin{aligned} F\prime(x) &= \frac{1}{\sin^2 x \cos^3 x} - \frac{4}{\cos^5 x} \\ &= \frac{\cos^2 x - 4\sin^2 x}{\sin^2 x \cos^5 x} \\ &= \frac{1 - 5\sin^2 x}{\sin^2 x \cos^5 x}. \end{aligned}$$

This is exactly the stated integrand, including its negative term and the fifth power of cosine. Hence $F + C$ supplies the required antiderivative.

Step 3: Exclude the remaining choices Option (C), $+\cot x$, gives $-F$ and therefore the negative of the required integrand. Options (A) and (B) instead produce reciprocal products $\mp 1/(\sin x \cos^5 x)$; their derivatives have numerator proportional to $1 - 6\sin^2 x$ over $\sin^2 x \cos^6 x$, so neither matches. These differences depend on x and cannot be absorbed into an additive integration constant.

Step 4: Conclusion

$$\int \frac{1 - 5\sin^2 x}{\cos^5 x \sin^2 x}\,dx = -\frac{\cot x}{\cos^5 x} + C.$$

Thus $f(x) = -\cot x$. Hence, the correct option is (D).

Quick Tip to Solve: When an MCQ supplies the form of an antiderivative, simplify each candidate first and differentiate; this checks both the sign and denominator powers directly.

16. If $f(x) = \frac{e^x}{1+e^x}$,

$I_1 = \int_{f(-a)}^{f(a)} xg\{x(1-x)\}dx$ **and**

$I_2 = \int_{f(-a)}^{f(a)} g\{x(1-x)\}dx$,

where g **is not an identity function. Then the value of** $\frac{I_2}{I_1}$ **is :** [4 marks]

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

(B) 2

(C) 1

(D) -1

Correct Answer: (B) 2

Solution:

Concept:

- The logistic function satisfies $f(-a) + f(a) = 1$. Thus the two integration limits are interchanged by $x \mapsto 1 - x$.
- The factor $x(1-x)$ is unchanged under this substitution. Definite-integral symmetry therefore relates an integral weighted by x to the same one weighted by $1 - x$.

Step 1: Relate the integration limits Write $\alpha = f(-a)$ and $\beta = f(a)$. From the stated definition,

$$\alpha = \frac{1}{1+e^a}, \qquad \beta = \frac{e^a}{1+e^a}, \qquad \alpha + \beta = 1.$$

Hence $1 - \alpha = \beta$ and $1 - \beta = \alpha$. This relation, rather than a particular formula for g, is the source of the required simplification.

Step 2: Reflect the weighted integral Set $x = 1 - t$, so $dx = -dt$. Reversing the transformed limits gives

$$\begin{aligned} I_1 &= \int_{\alpha}^{\beta} xg\{x(1-x)\}\,dx \\ &= \int_{\alpha}^{\beta} (1-t)g\{t(1-t)\}\,dt. \end{aligned}$$

The argument of g remains the same because $(1-t)t = t(1-t)$. The dummy integration variable may now be renamed x.

Step 3: Add the two expressions and interpret the ratio Adding the original and reflected expressions,

$$2I_1 = \int_{\alpha}^{\beta} [x + (1-x)]g\{x(1-x)\}\,dx = I_2.$$

Consequently, whenever the requested ratio is defined, $I_2/I_1 = 2$. Option (A) gives the reversed ratio, I_1/I_2, while (C) and (D) contradict the factor of two. As usual for this ratio question, existence of the integrals and a nonzero denominator are implicit: the statement that g is not the identity alone does not exclude a zero integral, but it does not change the symmetry identity whenever the ratio exists.

Step 4: Conclusion $I_2 = 2I_1$, so $\dfrac{I_2}{I_1} = 2$ whenever the ratio is defined. Hence, the correct option is (B).

Quick Tip to Solve: If the limits add to 1 and the integrand contains $g(x(1-x))$, replace x by $1 - x$ and add to remove a lone factor of x.

17. The area bounded by the curves $y^2 = 12x$ and $x^2 = 12y$ is divided by the line $x = 3$ in two parts. The area (in square units) of the larger part is : [4 marks]

(A) $\frac{147}{4}$

(B) $\frac{45}{4}$

(C) $\frac{137}{4}$

(D) $\frac{245}{4}$

Correct Answer: (A) $\frac{147}{4}$

Solution:

Concept:

- The area between curves expressed as upper and lower functions of x is the integral of upper minus lower over the horizontal range of the region.
- A vertical dividing line separates that integral at its own x-coordinate. Compute one portion and subtract it from the total to obtain the other.

Step 1: Locate the bounded region The equations imply $x \geq 0$ and $y \geq 0$. Substituting $y = x^2/12$ into $y^2 = 12x$ gives

$$\frac{x^4}{144} = 12x \quad \Longrightarrow \quad x(x^3 - 1728) = 0.$$

The intersections are $(0, 0)$ and $(12, 12)$. Between them the upper boundary is $y = \sqrt{12x}$, and the lower boundary is $y = x^2/12$. No negative branch of the first parabola bounds a further region with the second, since the latter requires nonnegative y.

Step 2: Integrate the total and left-hand areas For the full bounded region,

$$A = \int_0^{12} \left(\sqrt{12x} - \frac{x^2}{12}\right) dx$$
$$= \left[\frac{2\sqrt{12}}{3}x^{3/2} - \frac{x^3}{36}\right]_0^{12} = 96 - 48 = 48.$$

The part to the left of $x = 3$ has area

$$A_L = \left[\frac{2\sqrt{12}}{3}x^{3/2} - \frac{x^3}{36}\right]_0^{3} = 12 - \frac{3}{4} = \frac{45}{4}.$$

Both integrations use the same positive vertical separation.

Step 3: Compare the two portions The right-hand part is the remainder,

$$A_R = 48 - \frac{45}{4} = \frac{192 - 45}{4} = \frac{147}{4}.$$

Since $147/4 > 45/4$, this is the larger part. Option (B) is the smaller portion and so answers a different request. Options (C) and (D) do not agree with either definite integral or with the difference from the total area; in particular, $245/4$ already exceeds the total area 48.

Step 4: Conclusion The larger part has area $\frac{147}{4}$ square units. Hence, the correct option is (A).

Quick Tip to Solve: For two parabolas interchanged by x and y, find the common endpoints first, then use upper minus lower and subtract the smaller slice from the total.

18. Consider the differential equation, $ydx - \left(x + y^2\right) dy = 0$. If for $y = 1$, x takes value 1, then value of x when $y = 4$ is : [4 marks]

(A) 9

(B) 16

(C) 36

(D) 64

Correct Answer: (B) 16

Solution:

Concept:

- When an equation contains dx and dy, choose the dependent variable that makes the differential equation linear. Here x is a function of y.
- The linear equation $dx/dy + P(y)x = Q(y)$ has integrating factor $e^{\int P(y)dy}$; multiplying by it turns the left side into a product derivative.

Step 1: Put the equation in linear form The given equation is $y\,dx - (x + y^2)\,dy = 0$. On the positive interval joining the initial value $y = 1$ to the requested value $y = 4$, division by y is valid. Thus

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

This is linear in x, with $P(y) = -1/y$ and $Q(y) = y$. Trying to make y the dependent variable would obscure this simple linear structure.

Step 2: Use the integrating factor On $y > 0$, the integrating factor is

$$\text{IF} = e^{\int -1/y\,dy} = e^{-\log y} = \frac{1}{y}.$$

Multiplying the linear equation by it gives

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

Integrating with respect to y,

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

The integration constant is determined by the supplied point rather than discarded.

Step 3: Apply the initial value and check the answer At $y = 1$, the condition $x = 1$ gives $1 = 1 + C$, hence $C = 0$. Therefore $x = y^2$, and at $y = 4$ we obtain $x = 16$. As an independent check, $dx/dy = 2y$, so $y(dx/dy) - (x + y^2) = 2y^2 - (y^2 + y^2) = 0$. Thus the solution satisfies both the original differential equation and its initial condition. The other numerical options 9, 36 and 64 are not values of this uniquely determined solution at $y = 4$.

Step 4: Conclusion When $y = 4$, $x = 4^2 = 16$. Hence, the correct option is (B).

Quick Tip to Solve: If the coefficient of dx is y and the remaining term is linear in x, regard x as the dependent variable and look for the derivative of x/y.

19. The locus of the mid points of the chords of the parabola $x^2 = 4py$ having slope m is a : [4 marks]

(A) line parallel to x-axis at a distance $|2pm|$ from it.

(B) line parallel to y-axis at a distance $|2pm|$ from it.

(C) line parallel to $y = mx$, $m \neq 0$ at a distance $|2pm|$ from it.

(D) circle with centre at origin and radius $|2pm|$.

Correct Answer: (B) line parallel to y-axis at a distance $|2pm|$ from it.

Solution:

Concept:

- A chord of fixed slope m can be written as $y = mx + c$, where varying the intercept c changes the chord without changing its direction.
- For a quadratic equation $Ax^2 + Bx + C = 0$, the sum of its roots is $-B/A$. The midpoint abscissa of two endpoints is half the sum of their abscissae.

Step 1: Find the abscissae of the chord endpoints Substitute the equation of a chord into the parabola. If its endpoints have abscissae x_1, x_2, both satisfy

$$x^2 = 4p(mx + c), \qquad x^2 - 4pmx - 4pc = 0.$$

The root-sum relation therefore gives $x_1 + x_2 = 4pm$. This equation depends on the slope and the parabola parameter, but not on the variable intercept c. Hence it applies to every chord in the given parallel family.

Step 2: Use the midpoint formula and identify the line Let the midpoint be (h, k). Then

$$h = \frac{x_1 + x_2}{2} = 2pm.$$

Thus every midpoint lies on $x = 2pm$, a line parallel to the y-axis. Its perpendicular distance from that axis is $|2pm|$. Real nondegenerate chords occupy the appropriate portion of this diameter; this does not change the straight line containing their midpoints. In particular, for $p > 0$ their ordinates satisfy $k > pm^2$, with equality in the tangent limit.

Step 3: Compare the proposed geometric descriptions A line parallel to the x-axis would have a constant ordinate, whereas the calculation fixes the abscissa. A line parallel to $y = mx$ is generally oblique and does not agree with $x = 2pm$. A circle would require both coordinates to satisfy a quadratic relation; here there is just one linear condition. Thus only the vertical-line description matches the derived midpoint relation.

Step 4: Conclusion The midpoint locus lies on $x = 2pm$, parallel to the y-axis and at distance $|2pm|$ from it. Hence, the correct option is (B).

Quick Tip to Solve: For parallel chords, substitute $y = mx + c$ and use the sum of roots; the intercept disappears before the endpoints need to be calculated.

20. If the point $(p, 5)$ lies on the line parallel to the y-axis and passing through the intersection of the lines $2\left(a^2+1\right)x+by+4\left(a^3+a\right)=0$ and $\left(a^2+1\right)x-3by+2\left(a^3+a\right)=0$, then p is equal to : [4 marks]

(A) $-2a$

(B) $-3a$

(C) $2a$

(D) $3a$

Correct Answer: (A) $-2a$

Solution:

Concept:

- A line parallel to the y-axis has equation $x =$ constant. Every point on it has the same abscissa as the point through which it passes.
- Elimination removes a variable by combining equations with equal or opposite coefficients. The common factor $a^3 + a = a(a^2 + 1)$ simplifies the given line equations.

Step 1: Factor the two equations Write $A = a^2 + 1$, which is positive for every real a. The two line equations become

$$2Ax + by + 4aA = 0, \qquad Ax - 3by + 2aA = 0.$$

Equivalently, their terms containing x and their constants can be grouped as $2A(x + 2a) + by = 0$ and $A(x + 2a) - 3by = 0$. This exposes the same horizontal coordinate shift in both equations.

Step 2: Eliminate the ordinate of their intersection Multiply the first equation by 3 and add the second equation. The y-terms cancel without dividing by b:

$$7Ax + 14aA = 0.$$

Since $A = a^2 + 1 \neq 0$, division by $7A$ yields $x = -2a$. When the two stated lines have a unique intersection, substitution gives $by = 0$; its ordinate is immaterial to the requested vertical line. If $b = 0$, both displayed equations describe the same vertical line $x = -2a$, and the relevant abscissa is still fixed.

Step 3: Transfer the abscissa to the specified point The line through the intersection and parallel to the y-axis is therefore $x = -2a$. Because $(p, 5)$ lies on this line, its first coordinate must satisfy $p = -2a$. The supplied ordinate 5 does not enter the calculation: vertical motion changes only the second coordinate. The alternatives $-3a, 2a, 3a$ do not satisfy the eliminated equation in general; accidental agreement when $a = 0$ does not change the identity valid for every allowed parameter.

Step 4: Conclusion The required vertical line is $x = -2a$, so $p = -2a$. Hence, the correct option is (A).

Quick Tip to Solve: For a point on a vertical line through an intersection, calculate only the intersection abscissa; eliminate y rather than solving both coordinates.

21. If a circle has two of its diameters along the lines $x + y = 5$ and $x - y = 1$ and has area 9π, then the equation of the circle is : [4 marks]

(A) $x^2 + y^2 - 6x - 4y - 3 = 0$

(B) $x^2 + y^2 - 6x - 4y - 4 = 0$

(C) $x^2 + y^2 - 6x - 4y + 3 = 0$

(D) $x^2 + y^2 - 6x - 4y + 4 = 0$

Correct Answer: (D) $x^2 + y^2 - 6x - 4y + 4 = 0$

Solution:

Concept:

- Every diameter of a circle passes through its centre. Therefore, the intersection of two distinct diameter lines determines the centre.
- A circle of centre (h, k) and radius r has equation $(x - h)^2 + (y - k)^2 = r^2$ and area πr^2.

Step 1: Find the intersection of the diameter lines Let the centre be (h, k). Since it lies on both of the given diameter lines,

$$h + k = 5, \qquad h - k = 1.$$

Adding the equations gives $2h = 6$, hence $h = 3$. Substituting back gives $k = 2$. Thus the centre is $(3, 2)$. The lines specify directions of diameters, not tangent lines; no distance from the centre to either of these lines is needed.

Step 2: Calculate the squared radius from the area The area condition gives

$$\pi r^2 = 9\pi \quad \Longrightarrow \quad r^2 = 9.$$

The radius is positive, so $r = 3$. Insert the centre and the squared radius into the standard circle equation:

$$(x - 3)^2 + (y - 2)^2 = 9.$$

Both constraints have now been used: the diameter lines set the centre, while the area sets the size. The fact that the centre also lies inside the circle is automatic from this standard form.

Step 3: Expand and verify the constant term Expanding the squares gives

$$x^2 - 6x + 9 + y^2 - 4y + 4 = 9,$$

so the required equation is $x^2 + y^2 - 6x - 4y + 4 = 0$. All four proposed equations have the same linear terms and hence the same centre. If their constant term is C, completing squares gives $r^2 = 13 - C$. The constants $-3, -4, 3$ would yield squared radii $16, 17, 10$, respectively, whereas only $C = 4$ yields the required value 9. This also independently checks the expansion.

Step 4: Conclusion The circle is $(x - 3)^2 + (y - 2)^2 = 9$, or $x^2 + y^2 - 6x - 4y + 4 = 0$. Hence, the correct option is (D).

Quick Tip to Solve: When all circle options have the same linear terms, find the centre once and compare their constants using $r^2 = h^2 + k^2 - C$.

22. Let P be a point in the first quadrant lying on the ellipse $9x^2 + 16y^2 = 144$, such that the tangent at P to the ellipse is inclined at an angle 135° to the positive direction of x-axis. Then the coordinates of P are : [4 marks]

(A) $\left(\frac{\sqrt{143}}{3}, \frac{1}{4}\right)$

(B) $\left(\frac{8}{9}, \frac{\sqrt{77}}{3}\right)$

(C) $\left(\frac{4}{\sqrt{2}}, \frac{3}{\sqrt{2}}\right)$

(D) $\left(\frac{16}{5}, \frac{9}{5}\right)$

Correct Answer: (D) $\left(\frac{16}{5}, \frac{9}{5}\right)$

Solution:

Concept:

- The slope of a line inclined at angle θ to the positive x-axis is $\tan\theta$. Thus an inclination of 135° means slope -1.
- Implicit differentiation of an ellipse equation gives its tangent slope at a point. The desired point must satisfy both the ellipse equation and this slope condition.

Step 1: Differentiate the ellipse equation At $P = (x, y)$, differentiate $9x^2 + 16y^2 = 144$ with respect to x:

$$18x + 32y\frac{dy}{dx} = 0, \qquad \frac{dy}{dx} = -\frac{9x}{16y}.$$

The point lies in the first quadrant, so $x > 0$ and $y > 0$, in particular the denominator is nonzero. Equating the slope to $\tan 135^\circ = -1$ gives $9x = 16y$, or $y = 9x/16$.

Step 2: Combine the slope relation with the ellipse Substitute $y = 9x/16$ into the original equation:

$$9x^2 + 16\left(\frac{9x}{16}\right)^2 = 144, \qquad \frac{225}{16}x^2 = 144.$$

Consequently $x^2 = 256/25$. The first-quadrant condition selects the positive root $x = 16/5$, and then $y = (9/16)(16/5) = 9/5$. Taking both negative signs would give the corresponding third-quadrant point, which is outside the stated quadrant.

Step 3: Check the point and distinguish the options For $(16/5, 9/5)$, the ellipse expression is

$$9\frac{256}{25} + 16\frac{81}{25} = 144,$$

and the derivative equals $-9(16/5)/[16(9/5)] = -1$. These two checks verify both required conditions. In option (C), the point is on the ellipse but $9x/(16y) = 3/4$, giving slope $-3/4$, not -1. Options (A) and (B) also fail the required ratio $x/y = 16/9$. Merely belonging to the ellipse is not sufficient to select the answer.

Step 4: Conclusion The first-quadrant point is $P = (16/5, 9/5)$, where the tangent has slope -1. Hence, the correct option is (D).

Quick Tip to Solve: Find the coordinate ratio from the prescribed tangent slope first; substituting that ratio into the ellipse leaves a single quadratic equation.

23. A variable plane is at a constant distance p from the origin O and meets the set of rectangular axes OX_i $(i = 1, 2, 3)$ at points A_i $(i = 1, 2, 3)$, respectively. If planes are drawn through A_1, A_2, A_3, which are parallel to the coordinate planes, then the locus of their point of intersection is : [4 marks]

(A) $\frac{1}{x_1} + \frac{1}{x_2} + \frac{1}{x_3} = \frac{1}{p}$
(B) $\frac{1}{x_1^2} + \frac{1}{x_2^2} + \frac{1}{x_3^2} = \frac{1}{p^2}$
(C) $\frac{1}{x_1^3} + \frac{1}{x_2^3} + \frac{1}{x_3^3} = \frac{1}{p^3}$
(D) $x_1^2 + x_2^2 + x_3^2 = p^2$

Correct Answer: (B) $\frac{1}{x_1^2} + \frac{1}{x_2^2} + \frac{1}{x_3^2} = \frac{1}{p^2}$

Solution:

Concept:

- A plane with nonzero finite intercepts a_1, a_2, a_3 on three rectangular axes has equation $X_1/a_1 + X_2/a_2 + X_3/a_3 = 1$.
- The distance from the origin to $AX_1 + BX_2 + CX_3 + D = 0$ is $|D|/\sqrt{A^2 + B^2 + C^2}$. The squares appear because the normal length is Euclidean.

Step 1: Express the variable plane using its intercepts Write the three axis intercepts as

$$A_1 = (a_1, 0, 0), \quad A_2 = (0, a_2, 0), \quad A_3 = (0, 0, a_3).$$

The original plane is therefore $X_1/a_1 + X_2/a_2 + X_3/a_3 - 1 = 0$. Applying the point-to-plane distance formula at the origin gives

$$p = \frac{1}{\sqrt{a_1^{-2} + a_2^{-2} + a_3^{-2}}}.$$

Its intercepts may have either sign; their squares ensure the distance is nonnegative. The stated finite intercept construction concerns the cases in which these denominators are defined.

Step 2: Locate the intersection of the parallel planes The plane through A_1 parallel to the coordinate plane perpendicular to the first axis is $X_1 = a_1$. Similarly, the other two constructed planes are $X_2 = a_2$ and $X_3 = a_3$. Their common intersection consequently has coordinates $(x_1, x_2, x_3) = (a_1, a_2, a_3)$. Substitute these coordinates in the distance relation and square it to obtain

$$\frac{1}{x_1^2} + \frac{1}{x_2^2} + \frac{1}{x_3^2} = \frac{1}{p^2}.$$

Conversely, such a triple defines an intercept plane with exactly the stated origin distance, so the relation describes the required locus.

Step 3: Reject the other powers and the sphere Reciprocal first powers or third powers are not produced by the length of a plane normal and do not give the point-to-plane distance formula. The equation $x_1^2 + x_2^2 + x_3^2 = p^2$ would constrain the constructed intersection itself to lie at distance p from the origin. The question instead fixes the distance of the original plane, which is a different geometric condition. Therefore the reciprocal-square relation, not a sphere, is required.

Step 4: Conclusion The locus is $x_1^{-2} + x_2^{-2} + x_3^{-2} = p^{-2}$. Hence, the correct option is (B).

Quick Tip to Solve: Use intercept coordinates for the constructed intersection, then apply the origin-to-plane distance formula to the original plane.

24. If the lines $\frac{x-4}{1} = \frac{y-2}{1} = \frac{z-\lambda}{3}$ and $\frac{x}{1} = \frac{y+2}{2} = \frac{z}{4}$ intersect each other, then λ lies in the interval :

[4 marks]

(A) $(-5, -3)$

(B) $(13, 15)$

(C) $(11, 13)$

(D) $(9, 11)$

Correct Answer: (C) $(11, 13)$

Solution:

Concept:

- In a symmetric equation of a line, setting all ratios equal to one parameter gives coordinates of its general point. Use different parameters for different lines.
- Two spatial lines intersect only if one point satisfies all three coordinate equations simultaneously. The x- and y-coordinates can determine the parameters before checking z.

Step 1: Parameterise the two lines separately Let the ratios in the first line equal t, and those in the second line equal s. Their general points are

$$(4 + t,\ 2 + t,\ \lambda + 3t), \qquad (s,\ -2 + 2s,\ 4s).$$

The second coordinate of the latter point is $-2 + 2s$, since $(y + 2)/2 = s$. Keeping the offset -2 is essential. At an intersection the parameters need not be equal: they describe distances along different direction vectors from different starting points.

Step 2: Match the first two coordinates Equality of the x- and y-coordinates gives

$$4 + t = s, \qquad 2 + t = -2 + 2s.$$

Insert $s = 4 + t$ into the second equation:

$$2 + t = -2 + 2(4 + t) = 6 + 2t.$$

It follows that $t = -4$, and hence $s = 0$. These uniquely determine the possible intersection from the first two coordinates. The unknown λ affects only the height of the first line, so it is now fixed by the remaining coordinate equation.

Step 3: Match the third coordinate and choose the interval The equality of the z-coordinates requires $\lambda + 3t = 4s$. With the parameter values just found,

$$\lambda - 12 = 0 \quad \Longrightarrow \quad \lambda = 12.$$

The common point is $(0, -2, 0)$: substitution in either parametric line confirms it. Since $11 < 12 < 13$, the value belongs to $(11, 13)$. It is not in $(-5, -3)$, $(13, 15)$, or $(9, 11)$; each excludes 12. The parameters themselves, especially $t = -4$, must not be confused with the requested value of λ.

Step 4: Conclusion The lines intersect when $\lambda = 12$, which lies in $(11, 13)$. Hence, the correct option is (C).

Quick Tip to Solve: Use distinct parameters for the two lines; solve with two coordinates, then use the third coordinate to determine the unknown constant.

25. Unit vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ are coplanar. A unit vector $\vec{d}$ is perpendicular to them. If $(\vec{a}\times\vec{b})\times(\vec{c}\times\vec{d}) = \frac{1}{6}\hat{i}-\frac{1}{3}\hat{j}+\frac{1}{3}\hat{k}$ and the angle between $\vec{a}$ and $\vec{b}$ is 30°, then $\vec{c}$ is/are : [4 marks]

(A) $\pm\left(\frac{-\hat{i}-2\hat{j}+2\hat{k}}{3}\right)$

(B) $\left(\frac{2\hat{i}+\hat{j}-\hat{k}}{3}\right)$

(C) $\pm\left(\frac{-\hat{i}+2\hat{j}-2\hat{k}}{3}\right)$

(D) $\left(\frac{-2\hat{i}-2\hat{j}+\hat{k}}{3}\right)$

Correct Answer: (C) $\pm\left(\frac{-\hat{i}+2\hat{j}-2\hat{k}}{3}\right)$

Solution:

Concept:

- For unit vectors making an angle ϕ, the cross product has magnitude $\sin\phi$ and is normal to their plane.
- The vector triple-product identity is $\vec{u}\times(\vec{v}\times\vec{w}) = \vec{v}(\vec{u}\cdot\vec{w}) - \vec{w}(\vec{u}\cdot\vec{v})$.

Step 1: Express the normal vector The vectors $\vec{a},\vec{b},\vec{c}$ lie in one plane, whereas the unit vector $\vec{d}$ is perpendicular to that plane. Since the angle between $\vec{a}$ and $\vec{b}$ is 30°, their cross product has magnitude $1/2$. It may point along or opposite to $\vec{d}$. Therefore write

$$\vec{a}\times\vec{b} = \frac{\varepsilon}{2}\vec{d}, \qquad \varepsilon\in\{1,-1\}.$$

Step 2: Apply the triple-product identity Because $\vec{d}\cdot\vec{d}=1$ and $\vec{d}\cdot\vec{c}=0$,

$$\vec{d}\times(\vec{c}\times\vec{d}) = \vec{c}(\vec{d}\cdot\vec{d}) - \vec{d}(\vec{d}\cdot\vec{c}) = \vec{c}.$$

Substituting into the given equation gives

$$\frac{\varepsilon}{2}\vec{c} = \frac{1}{6}\hat{i}-\frac{1}{3}\hat{j}+\frac{1}{3}\hat{k}.$$

Multiplying by $2/\varepsilon = 2\varepsilon$ yields

$$\vec{c} = \varepsilon\frac{\hat{i}-2\hat{j}+2\hat{k}}{3} = \pm\frac{-\hat{i}+2\hat{j}-2\hat{k}}{3}.$$

Step 3: Check the direction and length The resulting vector has squared length $(1+4+4)/9 = 1$, so the unit-vector condition is satisfied. Its direction must be parallel to the given right-hand vector. Option (A) changes the relative signs of its components, while (B) and (D) have different component ratios. None of these can give the specified cross product. The two signs in (C) account for the two possible orientations of the normal.

Step 4: Conclusion $\vec{c} = \pm\frac{-\hat{i}+2\hat{j}-2\hat{k}}{3}$. Hence, the correct option is (C).

Quick Tip to Solve: When a cross product is normal to a common plane, write it as a signed multiple of the given unit normal before expanding the remaining triple product.

26. A biased coin with probability p, $0 < p < 1$, of heads is tossed until a head appears for the first time. If the probability that the number of tosses required is even is $\frac{2}{5}$, then p is equal to : [4 marks]

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

Correct Answer: (B) $\frac{1}{3}$

Solution:

Concept:

- If independent tosses have head probability p, the probability of the first head on toss n is $(1-p)^{n-1}p$.
- For $|r| < 1$, the infinite geometric series satisfies $1 + r + r^2 + \cdots = 1/(1-r)$.

Step 1: List the even stopping events Let $q = 1 - p$, so $0 < q < 1$. To stop at toss 2, the outcome must be TH, of probability qp. To stop at toss 4, it must be TTTH, of probability q^3p. More generally, stopping at toss $2k$ requires $2k - 1$ tails followed by one head. These events are mutually exclusive; their probabilities can therefore be added.

$$P(\text{even number of tosses}) = qp + q^3p + q^5p + \cdots .$$

Step 2: Sum the series and solve Factor out qp. The common ratio of the remaining geometric series is q^2, which lies strictly between 0 and 1:

$$P(\text{even}) = \frac{qp}{1-q^2} = \frac{qp}{(1-q)(1+q)} = \frac{q}{1+q}.$$

Here $1 - q = p$, so cancelling p is valid. Equating the result to the given probability gives

$$\frac{q}{1+q} = \frac{2}{5} \quad \Longrightarrow \quad 5q = 2 + 2q \quad \Longrightarrow \quad q = \frac{2}{3}.$$

Thus $p = 1 - q = 1/3$.

Step 3: Reject the other probabilities The formula can also be written $P(\text{even}) = (1-p)/(2-p)$. For options (A), (C) and (D), it gives respectively $1/3$, $3/7$ and $1/4$, none of which equals $2/5$. With $p = 1/3$, it gives $(2/3)/(5/3) = 2/5$, as required. The restriction $0 < p < 1$ also ensures that a head eventually occurs with probability one.

Step 4: Conclusion $p = \frac{1}{3}$. Hence, the correct option is (B).

Quick Tip to Solve: For a first-success stopping time, sum the odd powers of the failure probability as $pq/(1-q^2)$; cancel $p = 1 - q$ before solving.

27. If the mean and the standard deviation of 10 observations $x_1, x_2, \ldots\ldots, x_{10}$ are 2 and 3 respectively, then the mean of $(x_1+1)^2, (x_2+1)^2, \ldots\ldots, (x_{10}+1)^2$ is equal to : [4 marks]

(A) 13.5

(B) 14.4

(C) 16.0

(D) 18.0

Correct Answer: (D) 18.0

Solution:

Concept:

- The population variance of the observations is $\sigma^2 = \overline{x^2} - (\bar{x})^2$, where the bar denotes the mean over all observations.
- Means are linear: the mean of $x_i^2 + 2x_i + 1$ is $\overline{x^2} + 2\bar{x} + 1$.

Step 1: Recover the mean square The mean is $\bar{x} = 2$, and the standard deviation is $\sigma = 3$. The standard deviation must first be squared to obtain the variance. Therefore

$$\sigma^2 = 9 = \frac{1}{10}\sum_{i=1}^{10} x_i^2 - 2^2.$$

It follows that

$$\frac{1}{10}\sum_{i=1}^{10} x_i^2 = 9 + 4 = 13.$$

Equivalently, the sum of the observations is 20 and the sum of their squares is 130. This uses the variance of the stated set of observations, rather than the sample-variance estimator with denominator 9.

Step 2: Expand the transformed observations The requested quantity is the mean of the squares after adding 1 to each observation. Expand each square before averaging:

$$\begin{aligned}\frac{1}{10}\sum_{i=1}^{10}(x_i+1)^2 &= \frac{1}{10}\sum_{i=1}^{10}(x_i^2 + 2x_i + 1)\\ &= 13 + 2(2) + 1\\ &= 18.\end{aligned}$$

The constant term contributes 1 to the mean, since there are ten copies of 1 and the total is divided by ten.

Step 3: Verify by shifting the mean An independent check is to define $y_i = x_i + 1$. Adding the same constant to every observation changes the mean to 3 but leaves the standard deviation at 3. Thus $\overline{y^2} = \sigma_y^2 + (\bar{y})^2 = 9 + 9 = 18$. The alternatives 13.5, 14.4 and 16.0 do not satisfy this identity. In particular, simply squaring the new mean would give 9 and omit the spread of the data entirely.

Step 4: Conclusion The mean of $(x_i+1)^2$ is 18.0. Hence, the correct option is (D).

Quick Tip to Solve: For the mean of a squared shift, use $\overline{(x+c)^2} = \sigma^2 + (\bar{x}+c)^2$; the variance is unchanged by the shift.

28. A vertical pole stands at a point A on the boundary of a circular park of radius a and subtends an angle α at another point B on the boundary. If the chord AB subtends an angle α at the centre of the park, the height of the pole is : [4 marks]

(A) $2a \sin \frac{\alpha}{2} \tan \alpha$

(B) $2a \cos \frac{\alpha}{2} \tan \alpha$

(C) $2a \sin \frac{\alpha}{2} \cot \alpha$

(D) $2a \cos \frac{\alpha}{2} \cot \alpha$

Correct Answer: (A) $2a \sin \frac{\alpha}{2} \tan \alpha$

Solution:

Concept:

- In a circle of radius a, a chord subtending central angle α has length $2a \sin(\alpha/2)$.
- For a vertical height h viewed at elevation α from a point at horizontal distance d, $\tan \alpha = h/d$.

Step 1: Find the distance between the boundary points Let O be the centre of the park, and let T be the top of the pole erected at A. The triangle OAB has $OA = OB = a$ and $\angle AOB = \alpha$. Bisecting this isosceles triangle by the perpendicular from O to the chord gives a right triangle with hypotenuse a, opposite side $AB/2$ and angle $\alpha/2$. Hence

$$\frac{AB}{2} = a \sin \frac{\alpha}{2}, \qquad AB = 2a \sin \frac{\alpha}{2}.$$

Step 2: Use the angle subtended by the pole The pole is vertical and the park is horizontal, so TA is perpendicular to AB. The angle subtended by the pole at the boundary point B is $\angle ABT = \alpha$, since its lower end is A. In the right triangle BAT, with $h = TA$,

$$\tan \alpha = \frac{TA}{AB} = \frac{h}{2a \sin(\alpha/2)}.$$

Multiplication by the horizontal distance now gives

$$h = 2a \sin \frac{\alpha}{2} \tan \alpha.$$

Step 3: Check the trigonometric factors The half-angle sine comes from the chord, whereas the full-angle tangent comes from the height triangle. A cosine half-angle factor would describe the distance from the centre to the midpoint of the chord rather than half the chord itself. A cotangent would invert the opposite-to-adjacent ratio needed for the height. Thus options (B), (C) and (D) each replace at least one required factor incorrectly. For a positive finite pole, the elevation angle is acute, consistent with the tangent used above.

Step 4: Conclusion The pole has height $2a \sin \frac{\alpha}{2} \tan \alpha$. Hence, the correct option is (A).

Quick Tip to Solve: Use the central angle to find the chord first; then use that chord as the horizontal distance in the elevation triangle.

29. Let $\frac{3\pi}{4} < \theta < \pi$ and
$\sqrt{2\cot\theta + \frac{1}{\sin^2\theta}} = \mathrm{K} - \cot\theta$,
then K is equal to : [4 marks]

(A) -1

(B) 0

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

(D) 1

Correct Answer: (A) -1

Solution:

Concept:

- The identity $\csc^2\theta = 1 + \cot^2\theta$ converts the expression under the square root to a perfect square.
- The principal square root satisfies $\sqrt{u^2} = |u|$. Its sign must be decided from the given interval before removing the absolute value.

Step 1: Complete the square inside the radical Start with the exact expression printed in the question. The reciprocal of $\sin^2\theta$ is $\csc^2\theta$, so

$$2\cot\theta + \frac{1}{\sin^2\theta} = 2\cot\theta + 1 + \cot^2\theta$$
$$= (\cot\theta + 1)^2.$$

Consequently, the left side of the given equation is $|\cot\theta + 1|$. The square root is nonnegative by definition, so replacing it immediately with $\cot\theta + 1$ would be valid only if that quantity were nonnegative.

Step 2: Determine the sign using the interval The angle satisfies $3\pi/4 < \theta < \pi$, in the second quadrant. At $3\pi/4$, cotangent is -1, and it decreases to arbitrarily large negative values as θ approaches π from the left. More explicitly, write $\theta = \pi - \phi$, where $0 < \phi < \pi/4$. Then $\cot\theta = -\cot\phi < -1$. Hence $\cot\theta + 1 < 0$, giving

$$|\cot\theta + 1| = -\cot\theta - 1.$$

Step 3: Compare the two sides The original equation therefore becomes

$$-\cot\theta - 1 = K - \cot\theta.$$

Adding $\cot\theta$ to both sides leaves $K = -1$. The other proposed constants 0, $1/2$ and 1 cannot satisfy this equation anywhere throughout the specified interval. The excluded endpoint $\theta = \pi$ is also where cotangent is undefined, so no endpoint substitution is needed.

Step 4: Conclusion $K = -1$. Hence, the correct option is (A).

Quick Tip to Solve: After converting a radical to a square, retain the absolute value until the angle interval determines the sign of the enclosed expression.

30. Let p and q be any two propositions.

Statement 1 : $(p \to q) \leftrightarrow q \vee \sim p$ is a tautology.

Statement 2 : $\sim (\sim p \wedge q) \wedge (p \vee q) \leftrightarrow p$ is a fallacy. [4 marks]

(A) Both statement 1 and statement 2 are true.

(B) Both statement 1 and statement 2 are false.

(C) Statement 1 is true and statement 2 is false.

(D) Statement 1 is false and statement 2 is true.

Correct Answer: (C) Statement 1 is true and statement 2 is false.

Solution:

Concept:

- The implication $p \to q$ is logically equivalent to $\neg p \vee q$. A biconditional between equivalent propositions is a tautology.
- De Morgan's law gives $\neg(r \wedge s) = \neg r \vee \neg s$. A fallacy is false for every assignment, whereas a tautology is true for every assignment.

Step 1: Evaluate Statement 1 The right-hand proposition in Statement 1 is $q \vee \neg p$. By the implication identity and commutativity of disjunction,

$$p \to q \equiv \neg p \vee q \equiv q \vee \neg p.$$

Thus the two sides of the biconditional always have the same truth value. Their biconditional is true for every possible choice of p and q. The assertion that this is a tautology is therefore correct: Statement 1 is true.

Step 2: Simplify the left side of Statement 2 Apply De Morgan's law to the negated conjunction, and then distribute:

$$\begin{aligned} \neg(\neg p \wedge q) \wedge (p \vee q) &\equiv (p \vee \neg q) \wedge (p \vee q) \\ &\equiv p \vee (\neg q \wedge q) \\ &\equiv p \vee \text{False} \\ &\equiv p. \end{aligned}$$

The distributive step uses $(x \vee y) \wedge (x \vee z) \equiv x \vee (y \wedge z)$. The conjunction $\neg q \wedge q$ is always false regardless of the value of q.

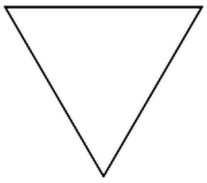
Step 3: Judge the claim of a fallacy Statement 2 places the simplified proposition in a biconditional with p. The full expression is therefore equivalent to $p \leftrightarrow p$, which is always true. It is a tautology, so the statement claiming that it is a fallacy is false. Option (A) incorrectly declares Statement 2 true; (B) incorrectly declares Statement 1 false; and (D) reverses both assessments. The term fallacy must be tested for the entire biconditional, not for an isolated component.

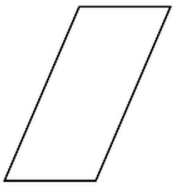
Step 4: Conclusion Statement 1 is true and Statement 2 is false. Hence, the correct option is (C).

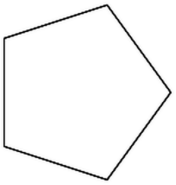
Quick Tip to Solve: Simplify each side of a biconditional first: if both reduce to the same proposition, the biconditional is a tautology.

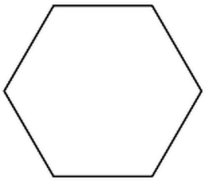
31. Directions : (For Q. 31 to 34). Find the odd figure out in the problem figures given below :

[4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A regular polygon has equal sides and equal interior angles. Its orientation on the page does not change that property.
- To find an odd figure, compare a geometric property shared by three figures rather than their apparent direction or number of sides.

Step 1: Identify the common class Figure (A) is an equilateral triangle, figure (C) is a regular pentagon and figure (D) is a regular hexagon. Their numbers of sides are respectively three, five and six, but within each figure all sides and all angles are equal. Turning the triangle upside down does not make it an irregular polygon. The pentagon and hexagon also retain their regularity when turned on the page.

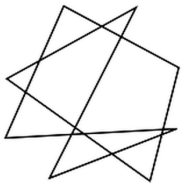
Step 2: Compare the quadrilateral with that class Figure (B) is an oblique parallelogram. It has equal opposite sides and equal opposite angles, but its adjacent angles are visibly different: one is acute and the next is obtuse. Consequently its four angles are not all equal, and it is not a regular quadrilateral. A regular quadrilateral would be a square. Merely having an even number of sides cannot distinguish (B), because (D) also has an even number of sides. Likewise, pointing downward does not distinguish the triangle geometrically. Regularity is the property that groups (A), (C) and (D), and excludes only (B).

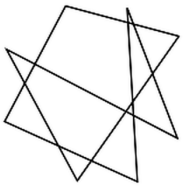
Step 3: Conclusion The oblique parallelogram is not a regular polygon, so it is the odd figure. Hence, the correct option is (B).

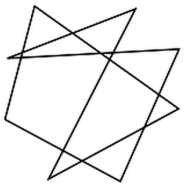
Quick Tip to Solve: For polygon odd-one-out questions, check equality of sides and angles before using side count or the direction in which a vertex points.

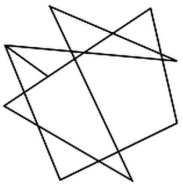
32. Directions : (For Q. 31 to 34). Find the odd figure out in the problem figures given below :

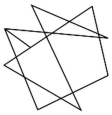
[4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A rotation changes the orientation of a figure but preserves the connections of its lines and their relative positions; a reflection reverses the handed arrangement.
- For a complicated intersecting outline, trace the boundary continuously through each crossing. Do not jump onto a different segment at an intersection.

Step 1: Trace the common line arrangement Start with (A) and follow its continuous eight-segment outline through the intersections, without changing branches. Its nearly horizontal segment lies across the lower part of the figure. Turn the figure through a quarter-turn anticlockwise: that segment becomes nearly vertical near the right side, and the projecting corners align with (B). Turn (A) through a half-turn instead: the same segment runs across the upper part, and the projecting corners align with (C). Thus (A), (B) and (C) have the same arrangement under rotations, despite their different orientations.

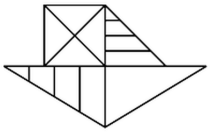
Step 2: Check the exceptional arrangement Compare (D) with (C), anchoring the comparison at their nearly horizontal upper segment and following the connected sharp corners. The corresponding corners fall on opposite left and right sides: (D) is the left-right reflected form of (C), rather than another turn of it. For example, the uppermost corner near the left in (C) corresponds to the uppermost corner near the right in (D), while the long nearly horizontal crossing segment also reverses its tilt. Following the adjacent outline segments confirms this reversed arrangement instead of a rotation. All options have eight line segments and similar projecting tips; those counts cannot identify the odd one. It is the handed geometric placement of the connected segments that separates the reflected figure from the three rotations.

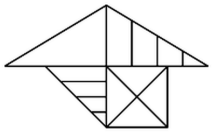
Step 3: Conclusion The reversed crossing arrangement is the odd figure. Hence, the correct option is (D).

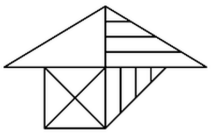
Quick Tip to Solve: Trace one continuous segment through a crossing and compare the next projecting corner; switching branches at a crossing can hide a reversed pattern.

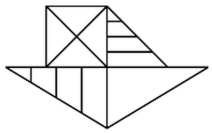
33. Directions : (For Q. 31 to 34). Find the odd figure out in the problem figures given below :

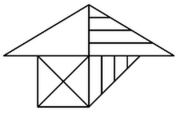
[4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A composite figure must be compared using both its outer boundary and its internal markings. A rotation preserves the relative positions of those markings.
- The crossed square, horizontally striped triangle, vertically striped triangle and unmarked triangle provide identifiable landmarks.

Step 1: Use the crossed square as a landmark In (A) and (D), the crossed square is above the left-hand part of the main horizontal line. A horizontally striped triangle is immediately to its right, a vertically striped triangle lies below the line on the left, and the large unmarked triangular region is below the line on the right. These two options have the same arrangement of the marked and unmarked regions. Now turn that arrangement through a half-turn: the crossed square moves to the lower right, the horizontally striped triangle moves to the lower left, and the vertically striped region moves to the upper right. This is the arrangement shown in (B).

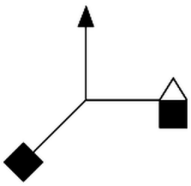
Step 2: Compare the remaining arrangement In (C), the crossed square is below the line on the left. The large unmarked triangle is above the line on the left, the horizontally striped triangle is above it on the right, and the vertically striped triangle is below on the right. The positions of these four distinctive regions do not follow from turning the common arrangement of (A), (B) and (D). A reflected arrangement changes their order around the centre, whereas a rotation preserves that order. All four options contain similar component shapes, so merely counting triangles or noting the crossed square would miss the difference.

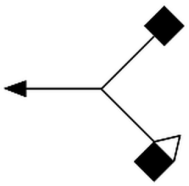
Step 3: Conclusion The reversed relative arrangement of the marked regions is the odd figure. Hence, the correct option is (C).

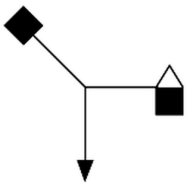
Quick Tip to Solve: Anchor a composite figure at its most distinctive component, then compare the neighbouring marked regions; the same outer silhouette can conceal a different arrangement.

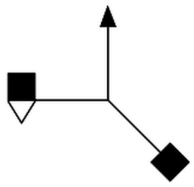
34. Directions : (For Q. 31 to 34). Find the odd figure out in the problem figures given below :

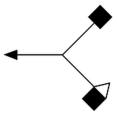
[4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Compare the angle between arms carrying the same two symbols. Turning the whole figure leaves that angle unchanged.
- The three terminal symbols are a filled arrowhead, a filled diamond and a house-like square with an unfilled triangular roof.

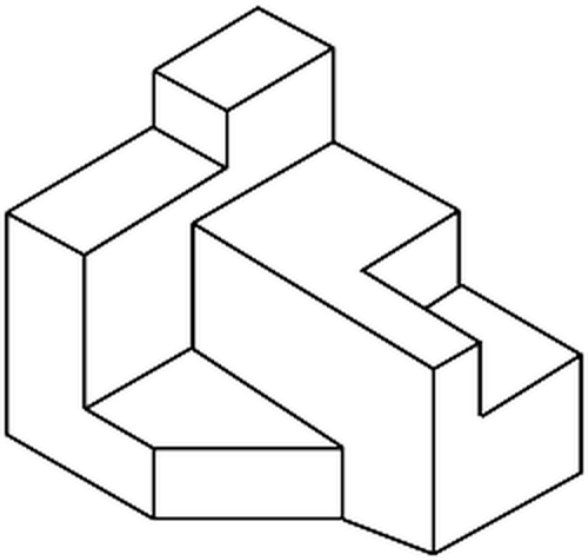
Step 1: Locate the right-angle pair in three figures In (A), the arrow arm points upward and the house arm points right, so those two arms are perpendicular. In (C), the arrow arm points downward and the house arm points right; again, they form a right angle. In (D), the arrow points upward and the house is on the left, so this same pair is perpendicular once more. In each of these three figures the diamond lies on the third, diagonal arm. Its arm makes an obtuse angle of approximately 135° with each of the two perpendicular arms.

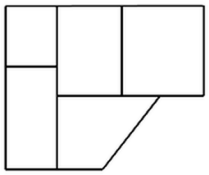
Step 2: Compare the marked arms in the exceptional figure In (B), the arrow arm points to the left. The diamond arm points towards the upper right and the house arm towards the lower right. The right angle is therefore between the diamond arm and the house arm, not between the arrow and house arms. The arrow now occupies the third arm, making an obtuse angle with each of the other two. Thus (B) changes which terminal symbol occupies the diagonal arm. Counting the three arms or the three symbols does not help because every figure has the same counts. The identity of the markers at the right-angle pair supplies the decisive distinction.

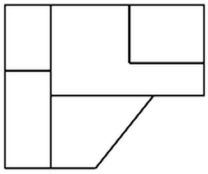
Step 3: Conclusion The figure in which the diamond and house, rather than the arrow and house, occupy perpendicular arms is the odd figure. Hence, the correct option is (B).

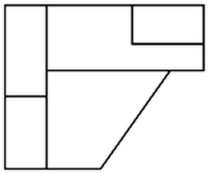
Quick Tip to Solve: Ignore the page orientation: first identify the two perpendicular arms, then compare the symbols at their ends.

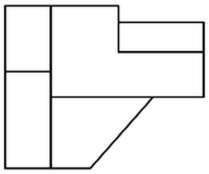
35. Directions : (For Q. 35 to 37). The 3 - D problem figure shows the view of an object. Identify, its correct top view, from amongst the answer figures. [4 marks]

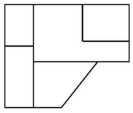


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A top view is obtained by looking vertically down. Heights disappear, but the horizontal footprint and the boundaries between visible top surfaces remain.
- A vertical face becomes an edge in plan. A step on a horizontal surface remains a line where the upper surface ends.

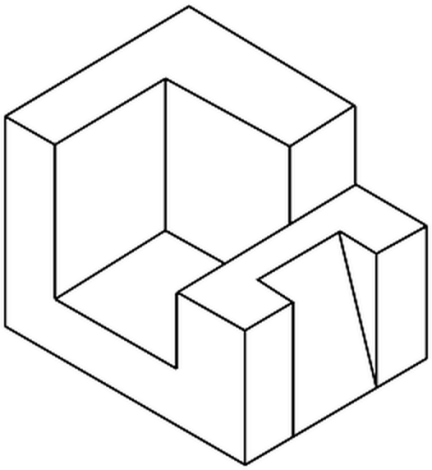
Step 1: Project the outer outline and raised surfaces Imagine moving the eye directly above the object without turning it sideways. The left-hand strip has a short higher block at its rear, so the plan must show a transverse line across that strip near the back. The central raised portion extends from the back towards the front on the right side of the left-hand recess. Its top also turns towards the right near the back, producing an L-shaped boundary in the central and right-hand portion of the plan. The sloping front edge of the lower platform remains a diagonal in the outer footprint; it is not removed merely because the view is from above.

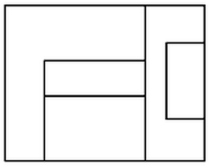
Step 2: Eliminate the inconsistent plans Option (B) preserves the long left strip with its short rear subdivision, the L-shaped upper region and the diagonal cut in the lower front outline. Option (A) divides the upper part by a straight full-height line instead of following the visible return of the raised surface. Option (C) places the subdivision of the left strip too far towards the front and does not reproduce the short raised rear block. Option (D) steps the rear outer boundary where the source object has a continuous rear footprint. Compare these boundaries as horizontal positions: do not copy the vertical edges of the perspective drawing as extra lines in the plan.

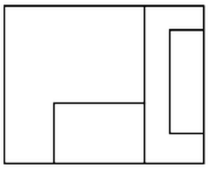
Step 3: Conclusion The plan that preserves the footprint, rear step and L-shaped raised surface is (B). Hence, the correct option is (B).

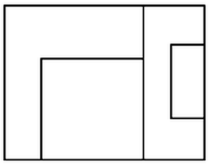
Quick Tip to Solve: For a stepped solid, trace the outer footprint first, then add only the edges where a visible horizontal surface changes level.

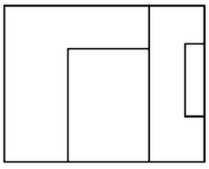
36. Directions : (For Q. 35 to 37). The 3 - D problem figure shows the view of an object. Identify, its correct top view, from amongst the answer figures. [4 marks]

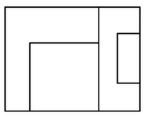


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- In a top view, vertical depth is suppressed while every point retains its horizontal position. A sloping visible face is represented by its horizontal extent.
- Compare both the outer footprint and the relative widths of raised strips and recesses; a similar-looking outline alone is insufficient.

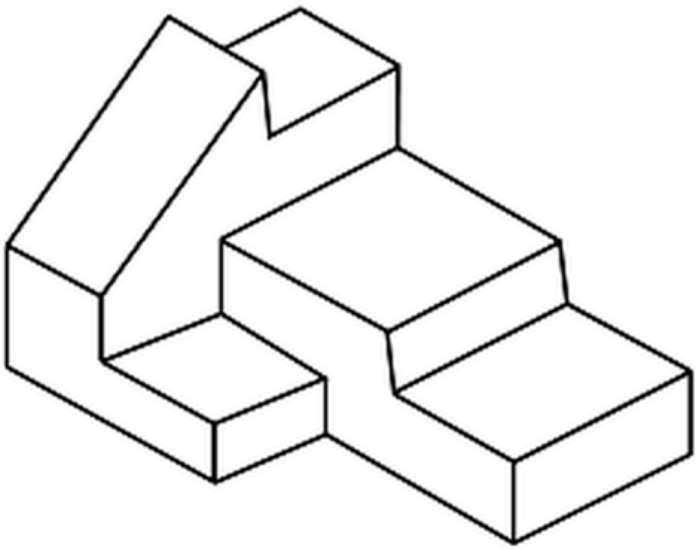
Step 1: Trace the solid from directly above The outside footprint is rectangular. Along the back and left sides, the higher top surface forms an L-shaped region around a lower central opening. The right side is occupied by a lower strip, containing a rectangular recess that opens towards the outside right edge. The sloping face visible in the perspective view does not mean that its plan edge is diagonal: its projection follows the rectangular limits of that recess. The left limb of the high L is narrower than the right-hand lower strip, and its inner corner occurs well before the middle of the depth of the plan.

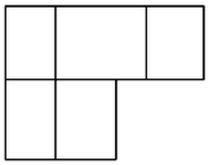
Step 2: Match the internal boundaries and proportions Option (C) shows the rectangular outline, a narrow left limb of the upper L, its horizontal inner boundary, and the right-hand strip with the correctly positioned rectangular indentation. Option (A) introduces an extra parallel line across the central region, which would imply another step that the given solid does not have. Option (B) gives the left-hand limb and the lower region the wrong relative widths and depths; its inner L corner is displaced too far towards the front. Option (D) similarly enlarges that limb and shifts the inner corner, while making the right-hand recess too narrow. These differences concern horizontal positions, so they remain visible even after all vertical heights have disappeared in the top view.

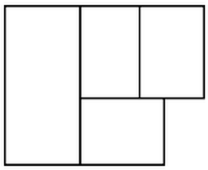
Step 3: Conclusion The correct top view, including the internal L-shaped boundary and right-side recess, is (C). Hence, the correct option is (C).

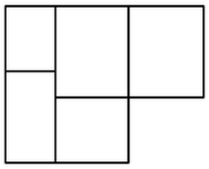
Quick Tip to Solve: Check the widths of the two side strips as well as the footprint; distractors often preserve the silhouette but move the inner corner of an L-shaped surface.

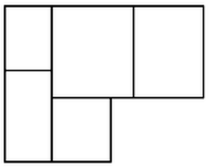
37. Directions : (For Q. 35 to 37). The 3 - D problem figure shows the view of an object. Identify, its correct top view, from amongst the answer figures. [4 marks]

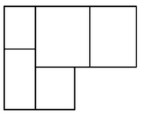


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A top view is an orthographic projection vertically downwards: height disappears, while the horizontal footprint and visible changes of surface remain.
- A sloping plane projects onto its horizontal strip. Its apparent slope in the pictorial view must not be mistaken for an extra boundary in the plan.

Step 1: Trace the footprint Follow the outside boundary of the object before considering its internal edges. The two arms form an L-shaped footprint: the back strip extends across the width, while the nearer portion stops short on the right. The cut-out must therefore stay at the lower right of the plan. Keep this orientation fixed when comparing the four alternatives; reflecting the object would give a different answer.

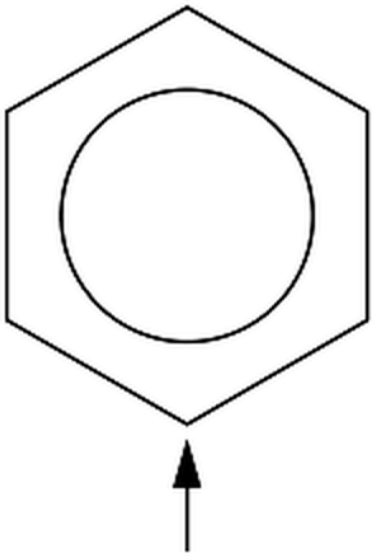
Step 2: Project the visible surface boundaries The long sloping face occupies the narrow strip along the left of the plan. Its junction with the adjoining higher surface is a longitudinal boundary, and the change near its rear end gives the short transverse line inside this strip. To its right, the raised middle platform and the lower projecting platform produce a transverse boundary with a short longitudinal continuation. Heights change the elevation of these edges, but not their positions in the horizontal projection.

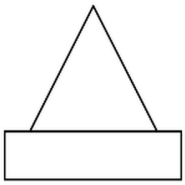
Step 3: Compare all four answer figures Option (D) retains the narrow left strip with its short transverse subdivision and places the central step boundaries at the correct offset. Option (A) carries the transverse division through the left strip at the wrong level. Option (B) makes the left strip unbroken and too broad. Option (C) shifts the lower central division so that it aligns with the wrong upper boundary. These differences concern actual projected edges, not shading or perspective.

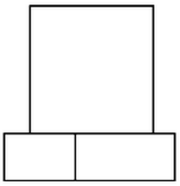
Step 4: Conclusion The correct top view is the L-shaped plan with the subdivisions shown in option (D). Hence, the correct option is (D).

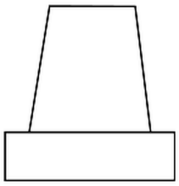
Quick Tip to Solve: First match the outer footprint, then follow one distinctive sloping strip and its junctions; do not use apparent pictorial lengths as plan dimensions.

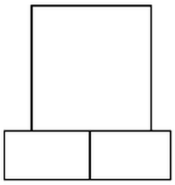
38. Directions : (For Q. 38 and 39). The problem figure shows the top view of an object. Identify the correct elevation, from amongst the answer figures, looking in the direction of arrow. [4 marks]

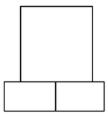


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An elevation is the orthographic view in the horizontal direction indicated by the arrow. The plan fixes the lateral arrangement of the visible vertical faces.
- A regular hexagonal base viewed towards a vertex has two front faces meeting at a central vertical edge. A circular upright surface has a rectangular elevation without an artificial central edge.

Step 1: Read the orientation of the base The outer boundary in the plan is a hexagon, with one vertex pointing towards the observer at the bottom of the figure. The arrow points directly towards that vertex. The elevation must therefore show the two adjacent front faces of the base meeting on a vertical line at the centre of the visible base. Looking at a vertex is different from looking squarely at one flat face; this orientation is the decisive feature here.

Step 2: Project the central circular feature The inner circle is centred on the base. Its front projection

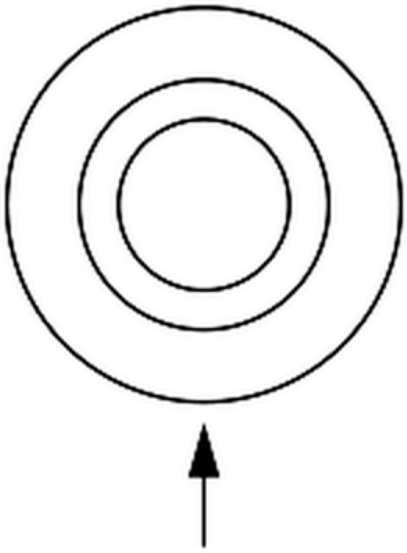
is the centred upright portion of the elevation. In the matching answer it is rectangular, as for a cylindrical feature, and it must be narrower than the overall projected base. The upright portion itself has no corner along its front centre, so it should not receive the vertical dividing line that belongs to the hexagonal base.

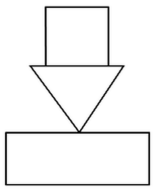
Step 3: Eliminate the inconsistent elevations Options (A) and (C) show triangular or tapered upright outlines and also omit the central meeting edge of the two front base faces. Option (B) does show an upright rectangle, but its base division lies noticeably to the left of the centre. This would not match the symmetric vertex-on direction of the supplied hexagonal plan. Option (D) places both the upright feature and the base meeting edge on the common vertical centre line, preserving the symmetry and the visible-face arrangement.

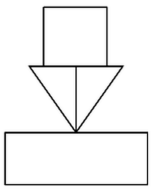
Step 4: Conclusion The elevation that agrees with the indicated direction and the centred base edge is option (D). Hence, the correct option is (D).

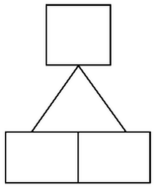
Quick Tip to Solve: When a hexagonal plan is viewed towards a vertex, look for a central vertical edge in the base elevation before comparing the upper feature.

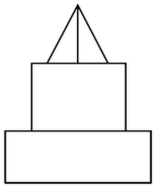
39. Directions : (For Q. 38 and 39). The problem figure shows the top view of an object. Identify the correct elevation, from amongst the answer figures, looking in the direction of arrow. [4 marks]

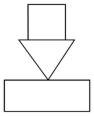


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- Concentric circles in a top view indicate coaxial circular boundaries with a common centre. Smooth surfaces of revolution do not introduce a vertical ridge in their elevation.
- To compare an elevation with a plan, match the outer base boundary and then the successive circular rims; do not treat a smooth conical outline as a faceted pyramid.

Step 1: Identify the three circular boundaries The plan contains three concentric circles and no straight polygonal boundaries. The largest circle is the circular base. The other two circles must be the rims of the upper coaxial features, centred over that base. In option (A), the broad base projects to a rectangle, the wider circular rim belongs to the flared inverted conical part, and the smaller circular rim belongs to the narrow cylindrical part above it. Their common axis produces the concentric arrangement seen from above.

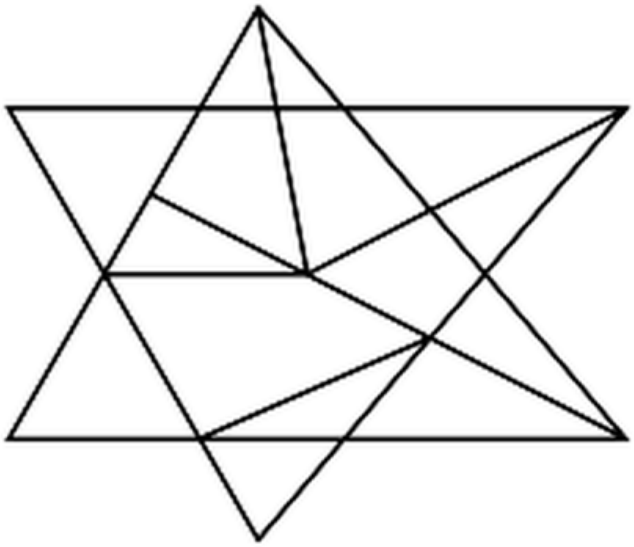
Step 2: Check the visible edges of the smooth parts The inverted conical part narrows downwards and widens towards its upper rim. In a front elevation its two outer generators make the triangular outline shown in (A). A smooth conical surface has no vertical corner down the middle, so there should be no solid centre seam inside this triangular outline. The cylinder likewise appears rectangular in elevation, with its curved surface giving no front centre edge.

Step 3: Compare the distractors Option (B) adds a solid central ridge to the inverted tapered part; that is inconsistent with the unbroken circular rim of a smooth coaxial form. Option (C) puts a central edge on the base, suggesting two planar front faces rather than a circular base, and reverses the arrangement of the tapered part. Option (D) similarly introduces a central ridge on the upper taper. Option (A) alone preserves the smooth circular character of all three boundaries without adding such a corner line.

Step 4: Conclusion The matching elevation is the coaxial assembly shown in option (A). Hence, the correct option is (A).

Quick Tip to Solve: For concentric circular plans, reject elevation lines that represent extra corners or ridges on surfaces intended to remain smooth and circular.

40. Directions : (For Q. 40 and 41). How many minimum number of straight lines are required to draw the problem figure ? [4 marks]



(A) 11

(B) 10

(C) 9

(D) 12

Correct Answer: (A) 11

Solution:

Concept:

- For a minimum straight-line count, count each maximal continuous straight stroke once. Crossings do not break a straight line into several new lines.
- Collinear pieces joined without a gap belong to one stroke; a change of direction requires another stroke, even when the pieces meet at the same vertex.

Step 1: Count the six long strokes of the star Begin with the two large overlapping triangles. One triangle has its upper vertex at the top of the picture and its horizontal base near the bottom. Its two sloping sides and base contribute three straight strokes. The other triangle has its horizontal side near the top and its lower vertex at the bottom. Its two sloping sides and horizontal side contribute three more. Their intersections are points on the same strokes and do not increase this subtotal. Thus the main star contributes six.

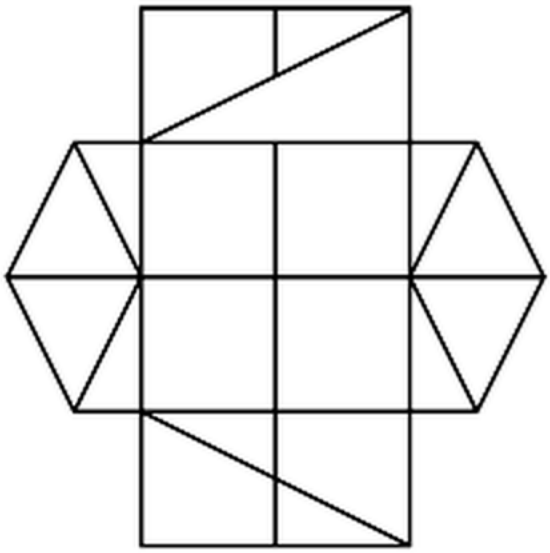
Step 2: Count the five added straight strokes Now ignore those six strokes and inspect only the additional interior connections. There is one stroke from the upper apex to the central junction; one horizontal stroke from the left inner crossing to the central junction; one rising stroke from that central junction to the upper-right outer vertex; one descending stroke passing through the central junction towards the lower-right outer vertex; and one rising stroke from the lower-left inner crossing to the right-lower inner junction. The descending connection remains a single straight stroke through its intermediate junction.

Step 3: Add and check the alternatives The total is therefore $6 + 5 = 11$. Each extra stroke has a direction or supporting line distinct from the six main strokes and from the other added strokes. Counting little pieces between crossings would overcount, while merging lines merely because they meet would undercount. Options (B) and (C) omit one or two necessary independent strokes. Option (D) counts an extra segment at an intersection even though that stroke continues straight through it.

Step 4: Conclusion The minimum number of straight lines is 11. Hence, the correct option is (A).

Quick Tip to Solve: Mark each full straight stroke mentally from endpoint to endpoint, passing through crossings without restarting the count.

41. Directions : (For Q. 40 and 41). How many minimum number of straight lines are required to draw the problem figure ? [4 marks]



(A) 18

(B) 19

(C) 20

(D) 21

Correct Answer: (B) 19

Solution:

Concept:

- A minimum straight-line count uses maximal connected collinear strokes. An intersection does not split a stroke, but a genuine gap between collinear pieces does.
- Grouping strokes by orientation prevents repeated counting: count horizontals, verticals, then the oblique strokes separately.

Step 1: Count the horizontal and vertical strokes There are five horizontal strokes: the top of the central rectangle, the line at the upper triangular attachments, the full middle line, the line at the

lower triangular attachments, and the bottom of the rectangle. For verticals, the left and right sides of the central rectangle each form one uninterrupted stroke. The middle vertical has a short upper piece ending on the upper diagonal, then a gap, followed by a longer piece from the next horizontal down to the bottom. These are two distinct strokes. Thus there are $5 + 4 = 9$ horizontal and vertical strokes in all.

Step 2: Count the side attachments Each side attachment contains four sloping strokes. On the left, two slopes form the outside boundary through the far-left vertex, and two inner slopes connect the middle junction to the upper and lower attachment corners. The right side has the same arrangement. Do not combine the upper and lower outside slopes at the side vertex: they change direction there. The two attachments therefore contribute $4 + 4 = 8$ oblique strokes.

Step 3: Include the remaining diagonals and total Inside the upper rectangular extension there is one diagonal from its lower-left corner to its upper-right corner. The lower extension contains one diagonal from its upper-left corner to its lower-right corner. These add two more, giving

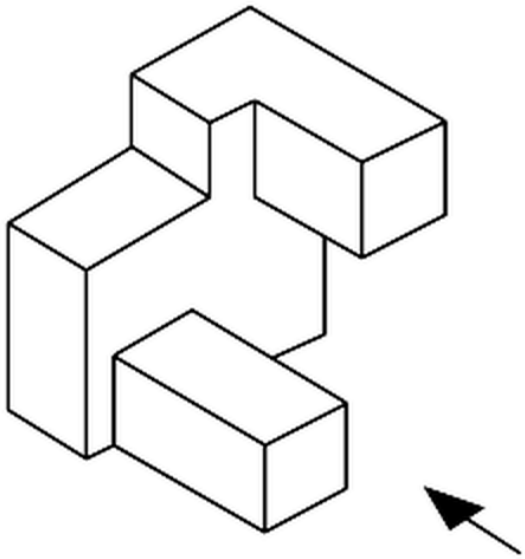
$$9 + 8 + 2 = 19.$$

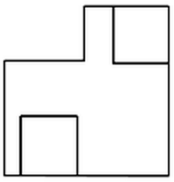
Option (A), 18, can result from joining the two separated pieces of the middle vertical across their gap. Options (C) and (D) overcount continuous strokes by splitting them at crossings or by counting part of an already counted straight line again.

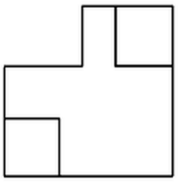
Step 4: Conclusion The minimum number of straight lines is 19. Hence, the correct option is (B).

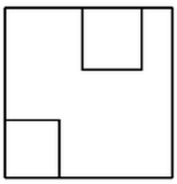
Quick Tip to Solve: After counting by direction, check the centre vertical carefully: its short upper piece is separated by a gap from the longer lower piece.

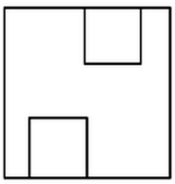
42. Directions : (For Q. 42 to 45). The 3 - D problem figure shows a view of an object. Identify the correct front view, from amongst the answer figures, looking in the direction of arrow. [4 marks]

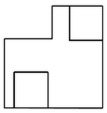


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A front view projects the object along the arrow, suppressing depth while retaining horizontal position, height and visible steps or recess edges.
- The arrow fixes the viewing side. A rotated or reflected outline cannot be substituted merely because it contains similar rectangular features.

Step 1: Fix the viewing direction and outer silhouette Look along the arrow from the lower-right of the pictorial view. The tall central web and the two projecting blocks overlap in depth in this direction. The upper block raises the silhouette on the right, while the left part of the object reaches only the lower shoulder. Consequently the front outline must have a step upwards towards the right. A simple full-height rectangle, as in options (C) and (D), would erase this visible difference of levels.

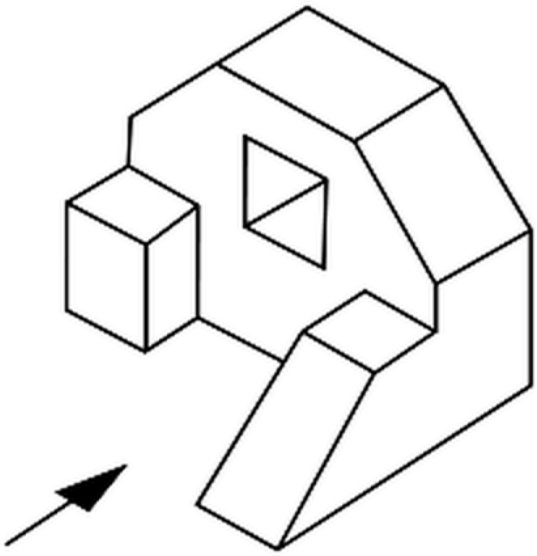
Step 2: Locate the lower and upper internal edges The lower projecting rectangular block occupies an offset position in front of the central web. Its visible upper boundary and upright side edges therefore form the small rectangular outline rising from the bottom, inset from the extreme left edge. At the top, the change of depth between the central web and the right projecting block creates the internal vertical boundary and the short horizontal return near the right edge. These two local features must retain their positions relative to the stepped outer silhouette.

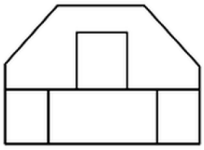
Step 3: Compare the candidate projections Option (A) combines the correct raised-right silhouette, the inset lower rectangular feature, and the right-hand upper return. Option (B) attaches the lower feature directly to the left outside edge, which loses the visible strip of the central face beside the projection. Option (C) gives a full rectangular outer outline and puts the lower feature on the edge. Option (D) also makes the outer top uniformly high. Neither of those silhouettes follows the change of height seen from the indicated direction.

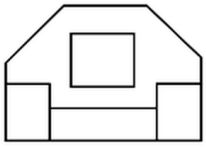
Step 4: Conclusion The correct front view from the arrow direction is option (A). Hence, the correct option is (A).

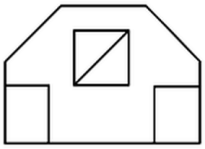
Quick Tip to Solve: Use the arrow first, then match the silhouette and one offset projecting block; these usually distinguish near-identical elevation options.

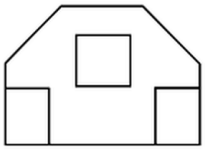
43. Directions : (For Q. 42 to 45). The 3 - D problem figure shows a view of an object. Identify the correct front view, from amongst the answer figures, looking in the direction of arrow. [4 marks]

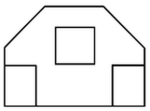


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A front view is an orthographic projection along the indicated arrow. Distances parallel to the viewing direction disappear; the horizontal positions and heights of visible edges remain.
- A sloping edge in the pictorial view is not necessarily a diagonal in the elevation. Decide whether it represents height variation or merely the depth of a recess.

Step 1: Identify the elevation outline Look along the arrow toward the main face of the object. The two lower projecting portions occupy the left and right sides, while the upper part has a horizontal top and two sloping shoulders. Thus the elevation has a roof-like upper outline with a rectangular opening in its central face. Preserve this outline rather than copying the oblique angles of the pictorial view.

Step 2: Project the opening and lower portions The central opening projects as a plain rectangle. The oblique segment visible inside it belongs to a surface extending backwards into the object; it does not form a diagonal across the front opening when depth is collapsed. The projecting lower left block

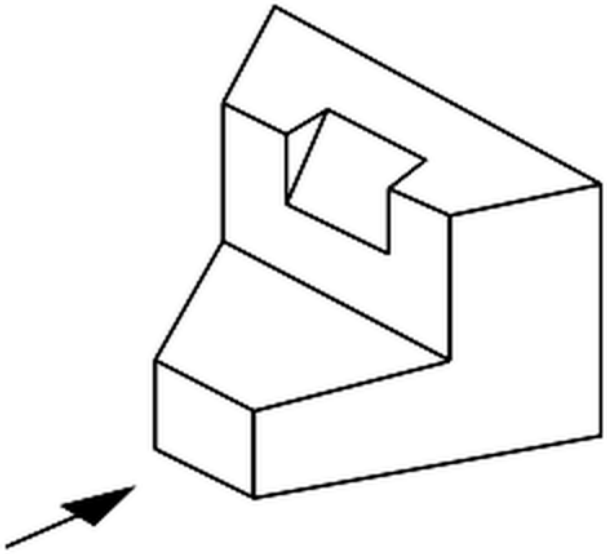
and the right-hand ramp give separate rectangular front areas at the sides. There is no continuous horizontal visible edge across the space between those two side areas.

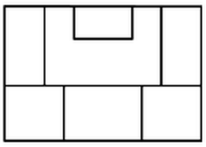
Step 3: Compare all the answer figures Option (D) has the required plain central rectangle, the two side rectangles and the correct outer profile. Option (C) incorrectly retains a diagonal inside the opening. Option (B) adds a continuous horizontal segment between the lower side areas. Option (A) also introduces a full horizontal subdivision and makes the central opening meet it, changing the relation of the opening to the lower portions. These extra lines are not edges of the required elevation.

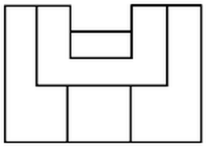
Step 4: Conclusion The correct front view has a plain rectangular opening and separate lower side rectangles, as in option (D). Hence, the correct option is (D).

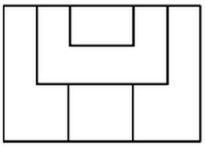
Quick Tip to Solve: For a recessed opening, first collapse its depth: an oblique return edge seen in perspective need not survive inside the front-view opening.

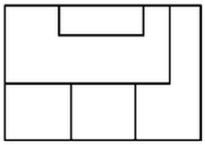
44. **Directions : (For Q. 42 to 45). The 3 - D problem figure shows a view of an object. Identify the correct front view, from amongst the answer figures, looking in the direction of arrow.** [4 marks]

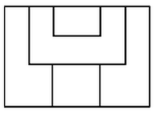


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An orthographic front view preserves the heights and transverse positions of the visible boundaries, while removing depth along the arrow.
- A notch can have material behind it: its apparent opening in a three-dimensional view need not break the outermost outline of the elevation.

Step 1: Separate the front step from the raised body View the object along the indicated arrow. The low projecting portion forms a base strip. Above it lies the taller body, with a recessed central notch. Follow the visible edges of the raised part and the step independently; this prevents the edge of the recess from being confused with the exterior outline. The rear material reaches the full upper level, so the elevation retains a continuous upper boundary.

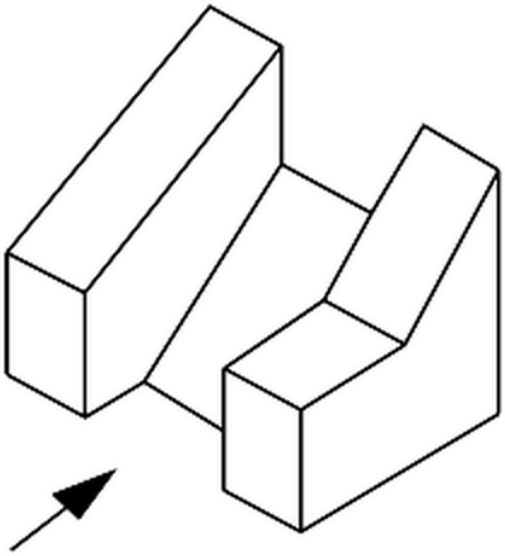
Step 2: Retain the recessed boundaries In the elevation, the raised front boundary has the form of a broad U: two vertical portions are joined by its lower horizontal edge. Inside its upper region, the smaller central recess gives another U-shaped outline descending from the top. Both outlines must be retained. The base region is subdivided by the projected vertical boundaries of the raised portion. Flattening the picture does not remove these visible changes of surface.

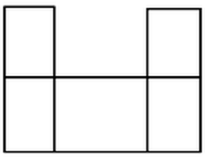
Step 3: Eliminate the alternatives Option (C) contains the continuous rectangular exterior, the broad U-shaped raised boundary, the smaller central notch and the correctly placed base subdivisions. Option (B) incorrectly opens the outside silhouette at the central notch and adds a horizontal segment across it. Option (A) reduces the lower edge of the raised region to a full-width horizontal division instead of the recessed U-shaped boundary. Option (D) omits the pair of upper side boundary lines needed to show the raised front region.

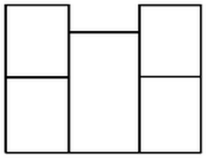
Step 4: Conclusion The projected arrangement of the raised body, central notch and lower step is shown by option (C). Hence, the correct option is (C).

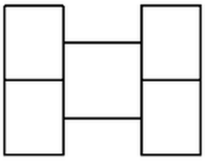
Quick Tip to Solve: Trace the exterior silhouette first, then add the broad recess and the smaller notch separately; a notch is not automatically a break in the outer silhouette.

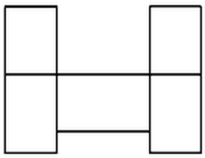
45. Directions : (For Q. 42 to 45). The 3 - D problem figure shows a view of an object. Identify the correct front view, from amongst the answer figures, looking in the direction of arrow. [4 marks]

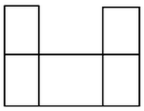


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- The arrow fixes the viewing direction. A front elevation shows transverse widths and vertical heights without the depth separation used in the pictorial drawing.
- Edges at different depths can project onto the same straight line. Count the resulting visible boundaries only once.

Step 1: Read the structure of the object The object has two raised longitudinal side portions with a lower channel between them. Along the arrow, the side portions project as two tall rectangular regions, and the channel gives the lower central region. The sloping surfaces run away from the observer; their oblique appearance in the drawing must not be copied directly into a front elevation.

Step 2: Project the common lower level Observe the level at which the lower central part meets the two side portions. In the front projection, this produces one common horizontal division across the whole width. The sides rise above this level, while the central portion does not. The lower boundary is

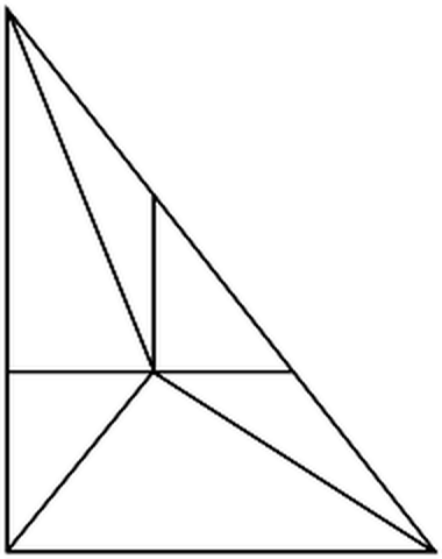
also continuous across the width: the middle is a low connecting region, rather than a second opening below a raised crossbar. Thus the outline is U-shaped above a full-width base.

Step 3: Test the proposed views Option (A) gives the two raised side regions, a central recess down to their common horizontal level, and a continuous rectangular base underneath. Option (B) raises the central connecting line to an incorrect level above the side subdivisions. Option (C) makes the central part extend higher and introduces an extra middle horizontal boundary. Option (D) inserts another lower horizontal edge across the centre, producing a central subdivision absent from the projected object. Only (A) keeps the same lower level across all three regions.

Step 4: Conclusion The front elevation has two raised sides and one common horizontal division above its full-width base. Hence, the correct option is (A).

Quick Tip to Solve: For channel-shaped solids, compare the level of the central floor with the horizontal edges on both side faces before matching the answer figures.

46. Directions : (For Q. 46 and 47). How many total number of triangles are there in the problem figure given below ? [4 marks]



(A) 11

(B) 12

(C) 10

(D) 9

Correct Answer: (B) 12

Solution:

Concept:

- A triangle counts only when all three sides are complete straight segments in the figure. A side may consist of several collinear pieces.

- Assign temporary labels to the vertices and classify triangles by the presence of an interior point. This counts large composite triangles as well as the smallest ones without duplication.

Step 1: Label the vertices unambiguously Call the top vertex A, the bottom-left vertex B and the bottom-right vertex C. Let O be the interior junction. Let D be the point where the horizontal through O meets AB, E its intersection with AC, and F the point on AC directly above O. The drawn segments are the three outer sides, DE, AO, BO, CO and OF. These labels are only for counting and do not add any segment to the problem figure.

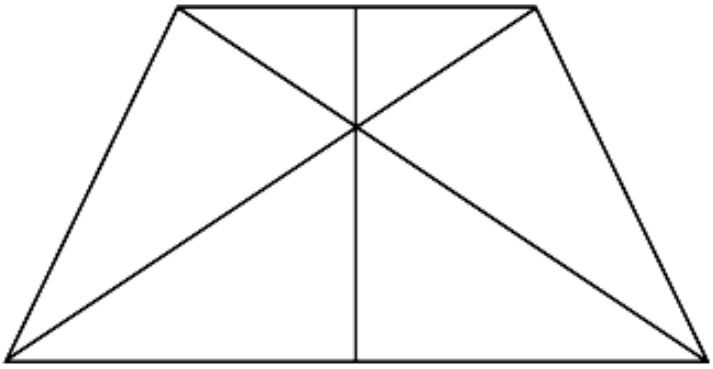
Step 2: Count the triangles containing O as a vertex With O as one vertex, the remaining two vertices must be joined by a drawn straight segment. Along AB they give ADO, BDO and ABO. Along AC they give AOF, AEO, ACO, EOF, COF and CEO. Along BC they give BCO. This produces ten distinct triangles. For example, ACO is larger than AEO and AOF but still counts because AC is one uninterrupted outer side; D, O and E do not form a triangle because they are collinear.

Step 3: Count those without O as a vertex There are two further triangles: ADE, whose base is the complete horizontal segment DE, and the outer triangle ABC. No other triple without O has all three connecting sides drawn. Consequently the total is ten plus two, or twelve. The alternatives 9, 10 and 11 omit at least one of these complete composite triangles; counting only the small visible regions would also be incomplete.

Step 4: Conclusion The total number of triangles is $10 + 2 = 12$. Hence, the correct option is (B).

Quick Tip to Solve: Fix the interior junction as a vertex first; then count the triangles that do not use it, including the entire outer triangle.

47. Directions : (For Q. 46 and 47). How many total number of triangles are there in the problem figure given below ? [4 marks]



(A) 12

(B) 13

(C) 11

(D) 14

Correct Answer: (A) 12

Solution:

Concept:

- Count a triangle only if each of its sides follows a continuous drawn straight line. Collinear triples and quadrilaterals do not count.
- Classify triangles by whether the crossing point of the diagonals is a vertex. This separates the small triangles from larger triangles built out of them.

Step 1: Label the trapezium and its intersections Call the lower-left and lower-right corners A and B, and the upper-right and upper-left corners C and D. Call the intersection of the two diagonals O. Let E be the midpoint of the lower base on the vertical line, and F the point where that vertical meets the upper base. The figure contains the four boundary sides, diagonals AC and BD, and the complete segment EF. No horizontal segment through O is drawn.

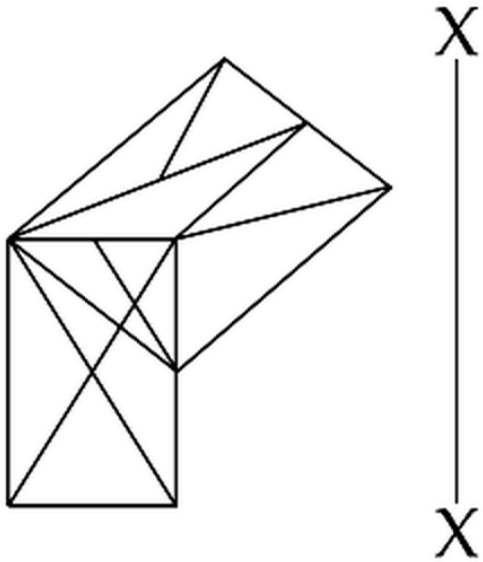
Step 2: Count the triangles with O as a vertex The triangles adjacent to the lower base are AEO and BEO, together with their combination ABO. Beside the left and right sloping boundaries are ADO and BCO. At the upper base there are DFO and CFO, together with their combination CDO. This gives eight distinct triangles using O. Do not count AOC or BOD: each of those triples lies on one straight diagonal, so it encloses no area.

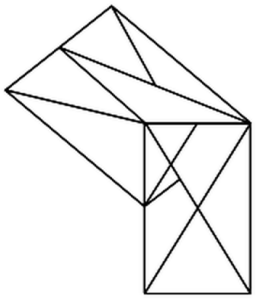
Step 3: Add the large triangles without O as a vertex Choosing three corners of the trapezium gives ABC, ABD, ACD and BCD, and every one has all its sides drawn. These four triangles do not have O as a vertex, even though O lies on a side of each. There are no further triangles using E or F without O because the necessary oblique connecting segments are not drawn. The total is therefore eight plus four, or twelve. The alternatives 11, 13 and 14 respectively miss a valid triangle or include nonexistent or degenerate ones.

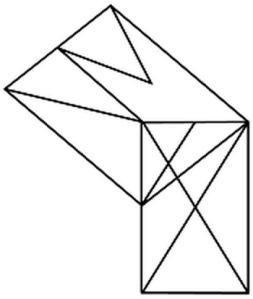
Step 4: Conclusion There are $8 + 4 = 12$ triangles in the problem figure. Hence, the correct option is (A).

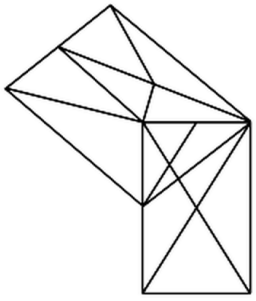
Quick Tip to Solve: At a diagonal crossing, exclude collinear triples before counting: the two ends of a diagonal and its crossing point never make a triangle.

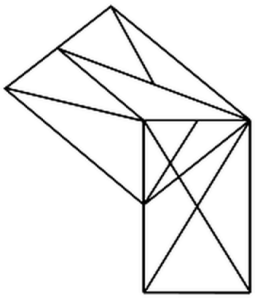
48. Directions : (For Q. 48 to 50). Which one of the answer figures is the correct mirror image of the problem figure with respect to X - X ? [4 marks]



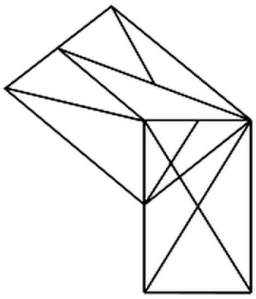
(A) 

(B) 

(C) 

(D) 

Correct Answer: (D)



Solution:

Concept:

- A vertical mirror reverses left and right while preserving heights, lengths and the pattern of connections. A rotation is not a mirror reflection.
- Every vertex must have an image at the same height and the same perpendicular distance on the opposite side of the mirror line. Connected endpoints remain connected.

Step 1: Reflect the outside arrangement The mirror line X–X is vertical and lies to the right of the problem figure. Thus the reflected figure has its upright rectangular portion on the right, with the sloping upper portion extending to the left. The top vertex, intermediate sloping vertex and every corner keep their original vertical levels. This first check eliminates a rotation or a change in the overall shape, but the internal connections must also be tested.

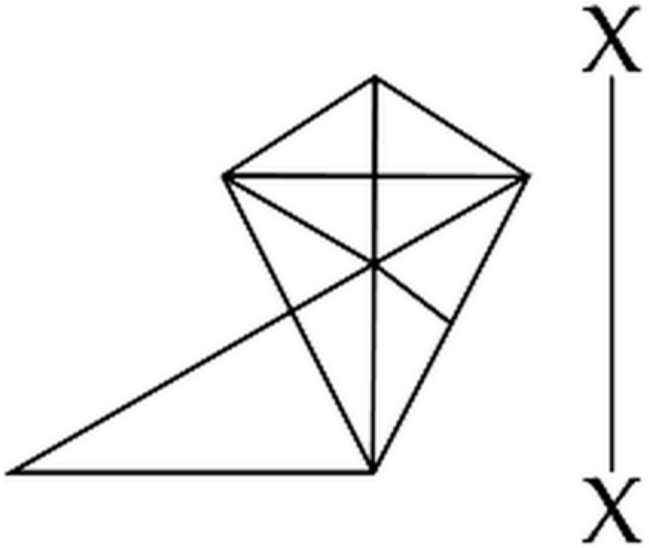
Step 2: Track the upper internal segments Follow the segments joining the upper apex, the intermediate point on the sloping edge and the central junction. After reflection, each connection is reversed horizontally. In particular, the short subdivision on the upper face must end on the reflected long diagonal at the corresponding junction, and must not be redirected toward a different corner. Option (D) preserves this network; options (B) and (C) change the connections in the upper sloping region.

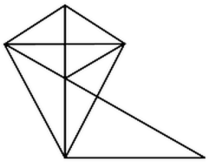
Step 3: Check the rectangular portion as well The original upright rectangle contains crossed diagonals and an additional broken connection from the upper edge toward the junction on its right side. Reflection places this extra junction on the left side of the upright rectangle. In option (D), the resulting crossings and endpoints occur in the reflected order. Option (A) has an incorrect extra internal connection in this region. Matching only the outline could overlook this difference, so both the upper part and the rectangular part must agree with the same left-right reversal.

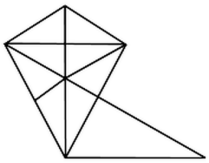
Step 4: Conclusion Option (D) preserves all the heights and internal connections under left-right reflection in X–X. Hence, the correct option is (D).

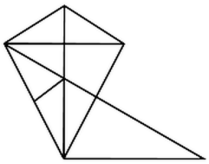
Quick Tip to Solve: Check one distinctive junction in the upper face and one in the rectangle; a matching outer silhouette alone does not establish the correct mirror image.

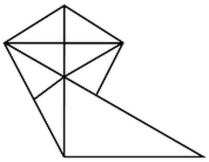
49. Directions (For Q. 48 to 50). Which one of the answer figures is the correct mirror image of the problem figure with respect to X–X? [4 marks]

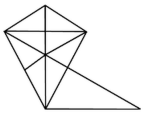


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Reflection in a vertical line reverses left and right while preserving the height of every point. It preserves straightness, intersections and the number of line segments.
- The asymmetric features are more useful than the approximately symmetric kite outline: track the long triangular extension and the shorter diagonal meeting a sloping side.

Step 1: Locate the asymmetric features The mirror X–X is vertical and lies to the right of the problem figure. In the original, a long line runs from the remote lower-left point through the central intersection to the upper-right corner of the kite. A separate shorter segment joins the upper-left corner through the centre to the lower portion of the right sloping side. These two lines must exchange their left-right positions, but their endpoints must remain at the same heights.

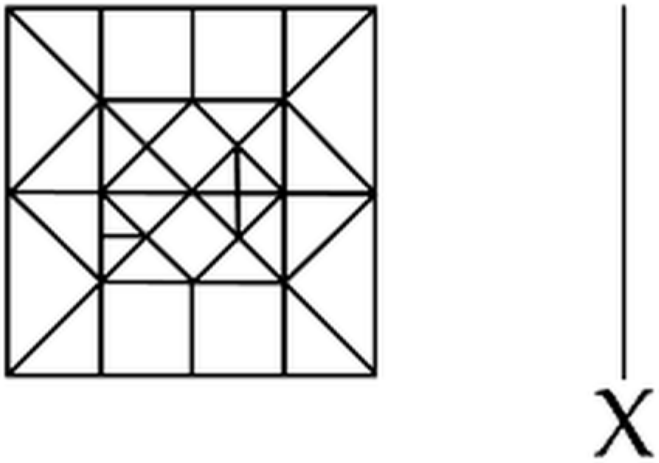
Step 2: Reflect the endpoints and compare the options After reflection, the remote point is at the lower right. The long line must run from the upper-left kite corner through the central intersection

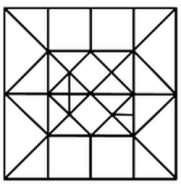
to that point. The short diagonal must run from the upper-right corner through the centre to the lower portion of the left sloping side. Option (B) has both relationships, together with the horizontal crossbar, vertical spine and complete kite boundary. Option (A) has the short diagonal on the wrong connection; (C) fails to carry the upper-right-to-centre segment; (D) changes the lower-left boundary and internal connections.

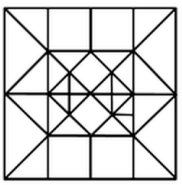
Step 3: Conclusion The complete reflected line network is shown in option (B). Hence, the correct option is (B).

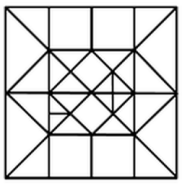
Quick Tip to Solve: For a complicated mirror image, identify one far-out endpoint and one short internal segment; both must reverse horizontally without changing height.

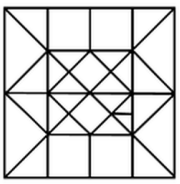
50. Directions (For Q. 48 to 50). Which one of the answer figures is the correct mirror image of the problem figure with respect to X–X? [4 marks]

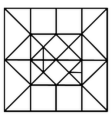


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A vertical mirror reverses horizontal positions only. A detail below the middle line remains below it, even though it moves to the opposite side.
- A square grid may look unchanged after reflection, so distinguish the options using the small additional strokes inside its central square rather than its outer boundary.

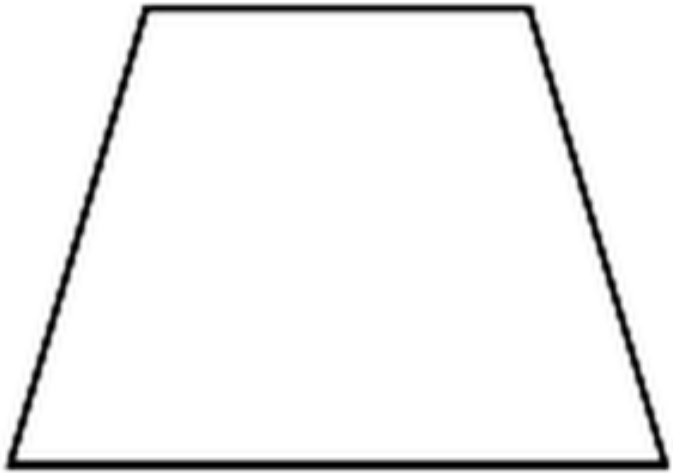
Step 1: Track the small distinguishing strokes The problem figure has a square outline, equally spaced vertical divisions, a horizontal middle line and several crossing diagonals. Most of these lines occur in nearly symmetric pairs. The useful asymmetric details are the short horizontal stroke in the lower-left part of the central square and the short vertical stroke in its right half. Under reflection, the horizontal stroke moves to the lower-right part, while the vertical stroke moves to the left half; neither changes its vertical level.

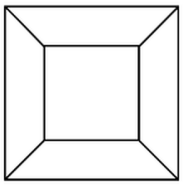
Step 2: Require both details to agree Option (A) places the extra horizontal stroke in the lower-right part and the extra vertical stroke in the left half of the central pattern. The diagonal endpoints and the surrounding grid also agree with the reflected original. Option (B) retains the vertical detail on the wrong side; option (C) leaves the lower horizontal detail on the left instead of the right; option (D) does not reproduce the required left-hand vertical detail. A choice based only on the large diagonals would miss these differences.

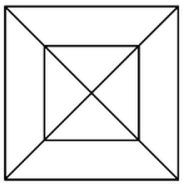
Step 3: Conclusion Option (A) preserves the grid and correctly reverses both distinguishing internal details. Hence, the correct option is (A).

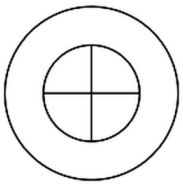
Quick Tip to Solve: Ignore the symmetric square border first; reflect the smallest unmatched stroke and then confirm a second internal feature.

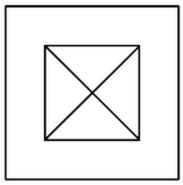
51. Directions (For Q. 51 and 52). The problem figure shows the elevation of an object. Identify the correct top view from amongst the answer figures. [4 marks]

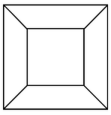


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An elevation is the orthographic view seen from the front; a top view shows the outline and visible edges seen vertically from above.
- For a square-based truncated pyramid, the smaller top square lies within the larger bottom square, and the four sloping edges join corresponding corners.

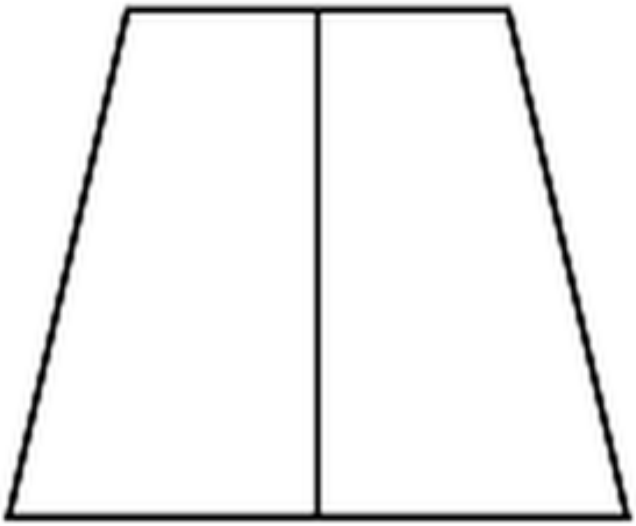
Step 1: Interpret the unbroken trapezoidal elevation The elevation has a shorter horizontal top, a longer horizontal base and two sloping sides, with no vertical edge through its interior. Among the proposed plans, the appropriate faceted solid is a square-based frustum seen square-on to one face. Its near top edge and near bottom edge give the two horizontal boundaries; its outside sloping edges give the two inclined boundaries. The top surface is a flat smaller square, so there is no apex at its centre.

Step 2: Match the visible plan edges Looking from above, the larger square is the outside footprint and the smaller square is the flat top face. Each corner of the top square connects to the corresponding corner of the base, producing the four diagonal corner segments shown in (A). In (B), the diagonals incorrectly continue across the flat top to a central crossing. In (C), the circular outlines and crossed centre do not give the required square-faced solid. In (D), the internal crossed square is disconnected from the outer corners, so it does not show the sloping edges of this frustum.

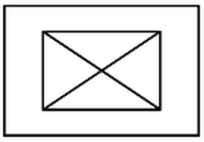
Step 3: Conclusion The nested squares with corresponding corners joined give the required top view. Hence, the correct option is (A).

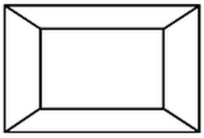
Quick Tip to Solve: For a truncated pyramid, draw the top face inside the base footprint and join corresponding corners; do not continue edges across a flat top.

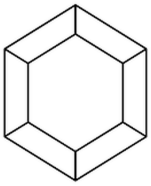
52. Directions (For Q. 51 and 52). The problem figure shows the elevation of an object. Identify the correct top view from amongst the answer figures. [4 marks]

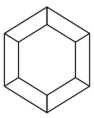


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- Visible edges in an elevation must have counterparts in the plan. A central vertical edge can distinguish a polygonal frustum from a square frustum viewed directly towards a face.
- The plan of a hexagonal frustum consists of two aligned similar hexagons, with their corresponding vertices joined by the sloping lateral edges.

Step 1: Use the centre line as evidence The silhouette is a trapezoid, but unlike a simple face-on square frustum, it contains a vertical line from the midpoint of the short upper edge to the midpoint of the longer lower edge. This line represents a visible edge of the solid, not a separate rectangular panel floating on the surface. A hexagonal frustum viewed towards a vertex has just this arrangement: the near upper and lower vertices project to the middle, and the outer vertices define the two sloping boundaries.

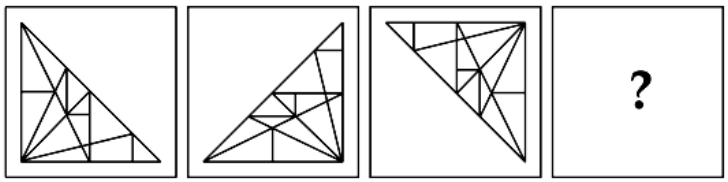
Step 2: Select the plan that retains this edge Option (D) shows a smaller hexagonal top inside a larger

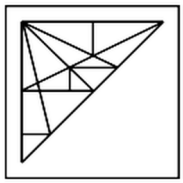
hexagonal base and connects corresponding corners. Its near vertex produces the middle vertical edge in the elevation, while the width decreases towards the top. Option (A), a subdivided rectangle, does not give the tapered polygonal object. Option (B) crosses the interior of the top rectangle and fails to connect its corners to the base. Option (C) is a square frustum viewed towards a face; its plan lacks the front central vertex responsible for the given middle edge.

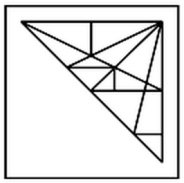
Step 3: Conclusion The hexagonal frustum in (D) gives the trapezoidal elevation with a central visible edge. Hence, the correct option is (D).

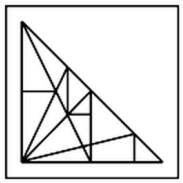
Quick Tip to Solve: When two elevations have the same silhouette, use their internal visible edges to determine whether the plan has a face or a vertex towards you.

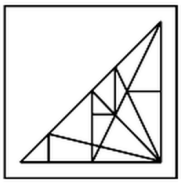
53. Directions (For Q. 53). Which one of the answer figures will complete the sequence of the three problem figures? [4 marks]

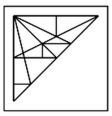


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A rigid rotation preserves all incidences: an internal line must keep the same endpoints relative to the triangle, even when its direction on the page changes.
- Find the transformation using the outer triangle, then check a distinctive internal junction to rule out a reflected or merely similar pattern.

Step 1: Determine the repeating quarter-turn The right-angled corner of the large triangle occurs successively at the lower left, lower right and upper right of its containing square. These positions follow equal quarter-turns in one direction around the square. The next right-angled corner must therefore be at the upper left. The entire internal network must undergo the same quarter-turn;

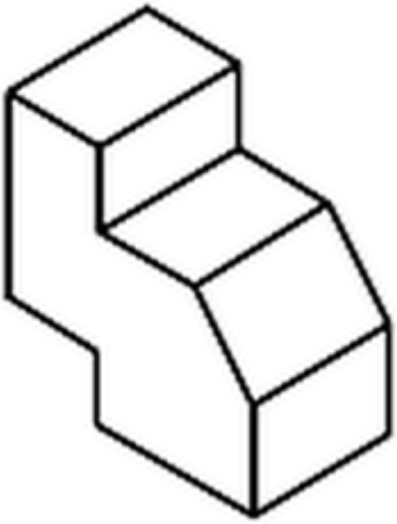
changing only the outline would not complete the sequence.

Step 2: Carry an internal landmark through the turn In the third problem figure, the multiple lines fan out from the upper-right region, and the short boundary subdivisions and triangular internal junctions are attached to particular sides. Turning that entire figure through the next quarter-turn puts the fan at the upper left, with the long horizontal top edge and the long vertical left edge bounding the triangle. Option (A) has the correct position of the short subdivisions and crossing lines. Option (B) leaves the right-angle corner at the upper right, (C) puts it at the lower left, and (D) puts it at the lower right; none advances the sequence to its next position.

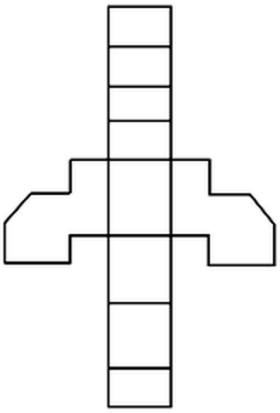
Step 3: Conclusion The next quarter-turn produces the triangular pattern in option (A). Hence, the correct option is (A).

Quick Tip to Solve: Track the large right-angle corner first, then rotate one unusual internal junction with it; a matching outline alone is insufficient.

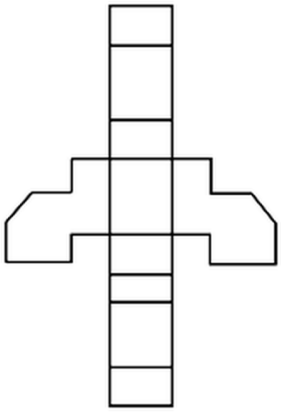
54. Directions (For Q. 54 and 55). Which one of the answer figures shows the correct view of the 3-D problem figure, after the problem figure is opened up? [4 marks]



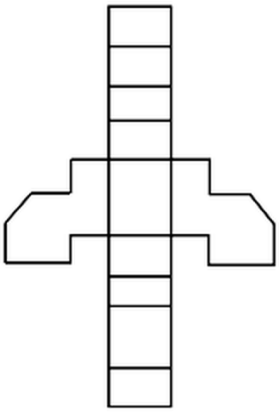
(A)



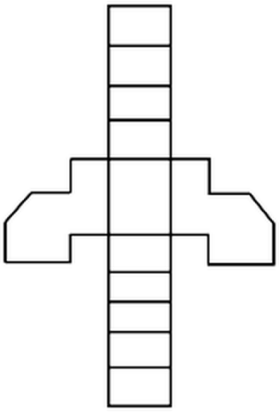
(B)



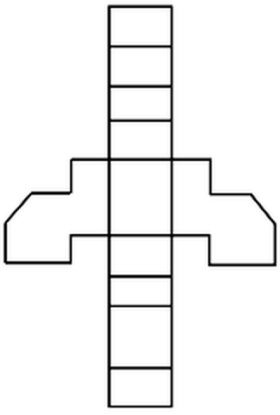
(C)



(D)



Correct Answer: (C)



Solution:

Concept:

- For a prism, the two end faces have the same outline. Its lateral surface unfolds into a strip with one rectangular panel for every edge of that outline.
- Adjacent panels must follow the perimeter in order. Their widths correspond to successive edge lengths; a fold cannot omit a ledge or merge a change in direction.

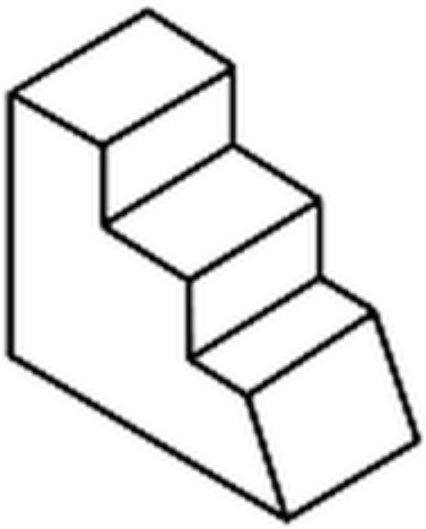
Step 1: Trace the stepped end profile The object is a prism with a stepped and bevelled side profile. Trace one end boundary continuously: the tall back, top ledge, short drop, intermediate ledge, inclined front portion, front drop, lower return, small upward step and remaining lower ledge. This gives nine boundary edges, so the development needs nine lateral rectangular panels, counting the central panel between the two end profiles. The two end profiles themselves must remain mirror counterparts attached on opposite sides of that strip.

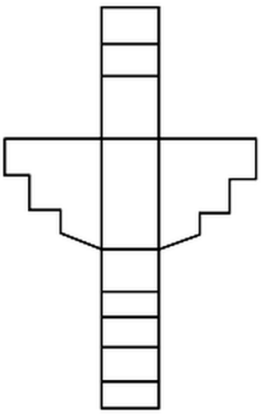
Step 2: Check every fold in the candidate strip Option (C) supplies the central panel and the four panels on each side needed to wrap around the complete nine-edge perimeter. Its divisions preserve the separate short step, tread and bevel portions, as well as the longer return; folding them successively closes against the matching second end. Options (A) and (B) each provide only eight lateral panels, omitting one required face, whereas (D) provides ten, adding an unnecessary fold through a face. Only (C) gives the nine panels required by the boundary. Merely having the correct end silhouette is not enough: a missing rectangular band leaves a face uncovered, while an extra division introduces an edge absent from the solid.

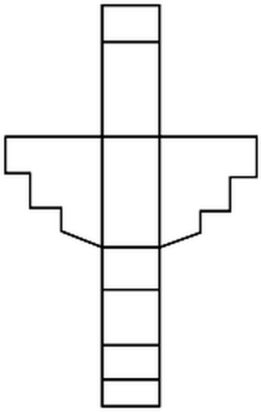
Step 3: Conclusion The complete unfolded surface, including every required lateral panel, is option (C). Hence, the correct option is (C).

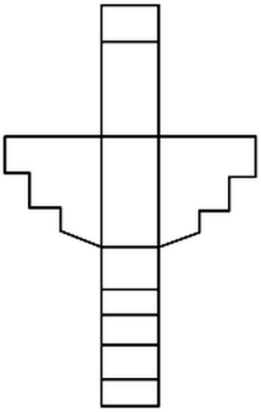
Quick Tip to Solve: Count the edges of the prism end profile before comparing its nets; count the central lateral panel as well as the panels above and below it.

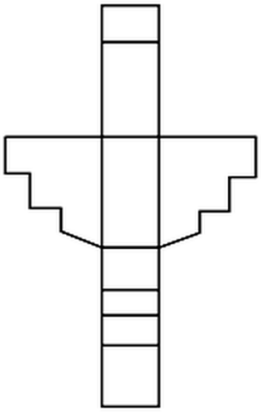
55. Directions: Which one of the answer figures shows the correct view of the 3-D problem figure after the problem figure is opened up? [4 marks]



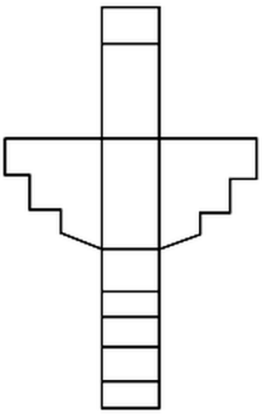
(A) 

(B) 

(C) 

(D) 

Correct Answer: (C)



Solution:

Concept:

- A net unfolds a solid without adding, removing or overlapping any of its faces. Each straight edge of a prism's end profile corresponds to one rectangular lateral face.
- The stepped object has two congruent end faces. Its end profile has eight edges: three horizontal tread edges, two vertical step edges, one inclined front edge, one bottom edge and one rear edge.

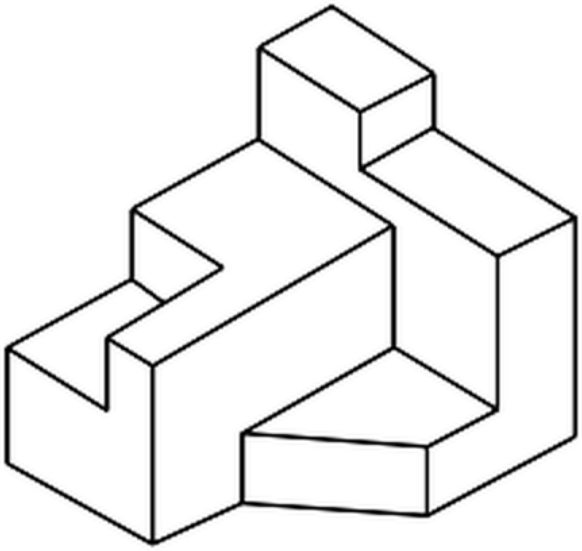
Step 1: Trace the boundary of an end face Begin at the highest tread and travel around the stepped outline. There are three tread segments separated by two drops. Continue down the inclined front, along the bottom and up the rear to return to the start. This gives eight boundary segments, so the unfolded band must contain exactly eight rectangular panels. The two stepped end pieces attach on opposite sides of this band; they do not replace any of its panels.

Step 2: Match the panels to the profile Count the intervals between fold lines along the central strip of each answer figure. Option (C) has eight panels, including the large panel between the two end pieces; its two panels above and five below supply the remaining seven. Their widths follow the successive boundary segments of the stepped profile. Option (A) has nine panels and therefore introduces an extra face. Options (B) and (D) each have only seven panels and miss a required face. Thus these three nets cannot close around the eight-edged end profile without an extra fold or an uncovered region.

Step 3: Conclusion The correct development is the net with eight lateral panels and the two matching stepped ends. Hence, the correct option is (C).

Quick Tip to Solve: For a stepped prism, count edges of the end profile first; the unfolded strip must contain exactly that many panels.

56. Find the total number of surfaces of the object given below in the problem figure. [4 marks]



(A) 14

(B) 15

(C) 17

(D) 16

Correct Answer: (D) 16

Solution:

Concept:

- A surface is a distinct planar face of the solid, rather than an edge or a corner. Faces that are hidden in the isometric view, including the underside, must also be counted.
- Count by orientation and level: horizontal terraces, vertical boundary faces, and any inclined faces. A change of height or a genuine fold separates faces; a single continuous coplanar region is counted once.

Step 1: Separate the horizontal regions Inspect the object from its lowest level upward. Identify the high rear cap, the intermediate platforms and the low recessed ledges. Count a connected planar terrace once, even when its outline has a notch or several corners. Do not count the black boundary lines themselves as surfaces, and do not split a continuous side merely because an edge of another platform ends against it.

Step 2: Complete the boundary and include hidden faces The narrow left recess and the lower right recess introduce boundary faces that are easy to miss. The highest rear block also has outer faces whose full extent is not visible from the viewing direction. Continue the count around the rear and underside of the solid; a face need not be visible in the given view to belong to its boundary. Sorting the boundary this way gives five exposed horizontal terraces, ten vertical boundary faces and one underside. Internal contacts between joined parts are excluded, because they are not exposed surfaces of the completed object.

Step 3: Add the disjoint face groups The groups count different portions of the boundary, so none is

counted twice. Their sum is

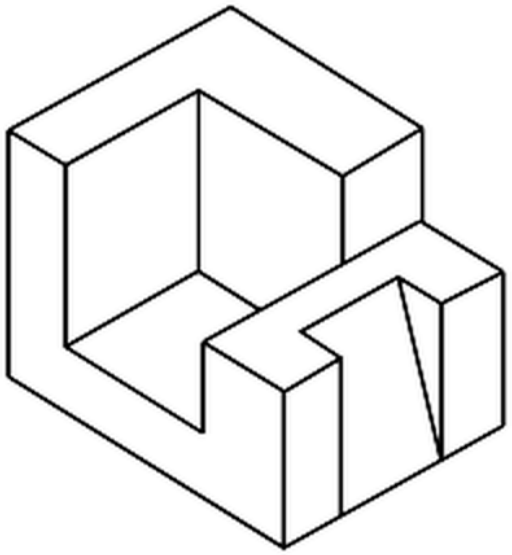
$$5 + 10 + 1 = 16.$$

The other offered totals, 14, 15, 17, do not account for the complete boundary: a smaller count omits a terrace, recess wall or hidden face, while a larger count splits a continuous face or counts an internal join. The requested total is therefore 16.

Step 4: Conclusion The object has 16 surfaces. Hence, the correct option is (D).

Quick Tip to Solve: Follow each terrace and recess around to the hidden side, then add the underside once. Count faces, not the visible edge strokes.

57. Find the total number of surfaces of the object given below in the problem figure. [4 marks]



(A) 15

(B) 16

(C) 14

(D) 13

Correct Answer: (B) 16

Solution:

Concept:

- A surface is a distinct planar face of the solid, rather than an edge or a corner. Faces that are hidden in the isometric view, including the underside, must also be counted.
- Count by orientation and level: horizontal terraces, vertical boundary faces, and any inclined faces. A change of height or a genuine fold separates faces; a single continuous coplanar region is counted once.

Step 1: Separate the horizontal regions Inspect the object from its lowest level upward. Identify the high U-shaped rim, the recessed floor and the lower front rim. Count a connected planar terrace

once, even when its outline has a notch or several corners. Do not count the black boundary lines themselves as surfaces, and do not split a continuous side merely because an edge of another platform ends against it.

Step 2: Complete the boundary and include hidden faces The diagonal line inside the front recess is an actual boundary of an inclined face. It must be counted as a face of its own, rather than treating the recess as an ordinary rectangular opening. Continue the count around the rear and underside of the solid; a face need not be visible in the given view to belong to its boundary. Sorting the boundary this way gives three exposed horizontal regions, eleven vertical faces, one inclined face and one underside. Internal contacts between joined parts are excluded, because they are not exposed surfaces of the completed object.

Step 3: Add the disjoint face groups The groups count different portions of the boundary, so none is counted twice. Their sum is

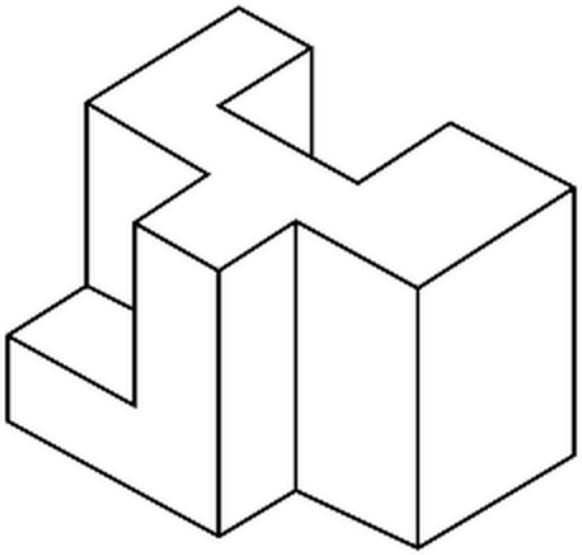
$$3 + 11 + 1 + 1 = 16.$$

The other offered totals, 15, 14, 13, do not account for the complete boundary: a smaller count omits a terrace, recess wall or hidden face, while a larger count splits a continuous face or counts an internal join. The requested total is therefore 16.

Step 4: Conclusion The object has 16 surfaces. Hence, the correct option is (B).

Quick Tip to Solve: Follow each terrace and recess around to the hidden side, then add the underside once. Count faces, not the visible edge strokes.

58. Find the total number of surfaces of the object given below in the problem figure. [4 marks]



(A) 15

(B) 12

(C) 13

(D) 14

Correct Answer: (A) 15

Solution:

Concept:

- A surface is a distinct planar face of the solid, rather than an edge or a corner. Faces that are hidden in the isometric view, including the underside, must also be counted.
- Count by orientation and level: horizontal terraces, vertical boundary faces, and any inclined faces. A change of height or a genuine fold separates faces; a single continuous coplanar region is counted once.

Step 1: Separate the horizontal regions Inspect the object from its lowest level upward. Identify the connected upper cross-shaped region and the lower projecting ledge. Count a connected planar terrace once, even when its outline has a notch or several corners. Do not count the black boundary lines themselves as surfaces, and do not split a continuous side merely because an edge of another platform ends against it.

Step 2: Complete the boundary and include hidden faces Trace all twelve changes of direction around the cross-shaped plan, including its inward corners. Each corresponding vertical boundary wall contributes a separate surface; the lower ledge adds a horizontal surface without making the connected upper region several separate faces. Continue the count around the rear and underside of the solid; a face need not be visible in the given view to belong to its boundary. Sorting the boundary this way gives two exposed horizontal levels, twelve vertical boundary faces and one underside. Internal contacts between joined parts are excluded, because they are not exposed surfaces of the completed object.

Step 3: Add the disjoint face groups The groups count different portions of the boundary, so none is counted twice. Their sum is

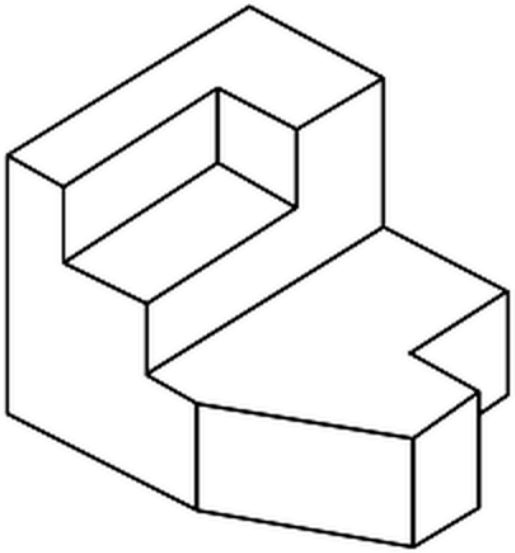
$$2 + 12 + 1 = 15.$$

The other offered totals, 12, 13, 14, do not account for the complete boundary: a smaller count omits a terrace, recess wall or hidden face, while a larger count splits a continuous face or counts an internal join. The requested total is therefore 15.

Step 4: Conclusion The object has 15 surfaces. Hence, the correct option is (A).

Quick Tip to Solve: Follow each terrace and recess around to the hidden side, then add the underside once. Count faces, not the visible edge strokes.

59. Find the total number of surfaces of the object given below in the problem figure. [4 marks]



(A) 11

(B) 12

(C) 14

(D) 15

Correct Answer: (C) 14

Solution:

Concept:

- A surface is a distinct planar face of the solid, rather than an edge or a corner. Faces that are hidden in the isometric view, including the underside, must also be counted.
- Count by orientation and level: horizontal terraces, vertical boundary faces, and any inclined faces. A change of height or a genuine fold separates faces; a single continuous coplanar region is counted once.

Step 1: Separate the horizontal regions Inspect the object from its lowest level upward. Identify the raised rear rim, its recessed interior shelf and the broad lower front platform. Count a connected planar terrace once, even when its outline has a notch or several corners. Do not count the black boundary lines themselves as surfaces, and do not split a continuous side merely because an edge of another platform ends against it.

Step 2: Complete the boundary and include hidden faces The re-entrant notch on the right of the front platform has short boundary walls of its own. The sloping-looking front edge is due to the plan shape in this view; it does not split the whole level top into multiple faces. Continue the count around the rear and underside of the solid; a face need not be visible in the given view to belong to its boundary. Sorting the boundary this way gives three exposed horizontal levels, ten vertical boundary faces and one underside. Internal contacts between joined parts are excluded, because they are not exposed surfaces of the completed object.

Step 3: Add the disjoint face groups The groups count different portions of the boundary, so none is

counted twice. Their sum is

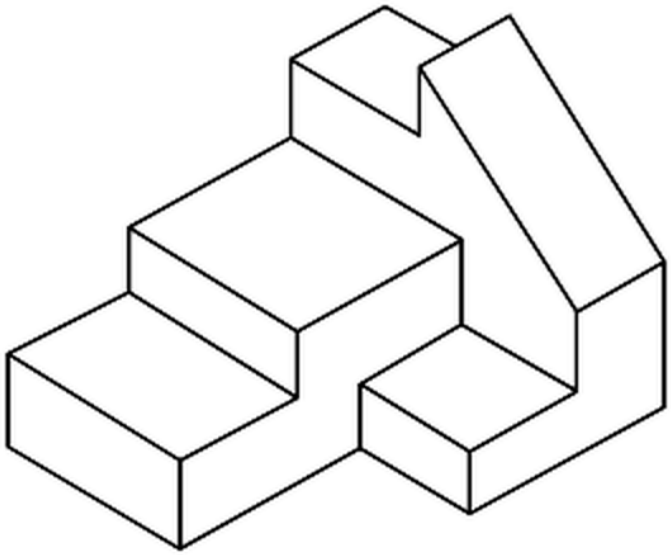
$$3 + 10 + 1 = 14.$$

The other offered totals, 11, 12, 15, do not account for the complete boundary: a smaller count omits a terrace, recess wall or hidden face, while a larger count splits a continuous face or counts an internal join. The requested total is therefore 14.

Step 4: Conclusion The object has 14 surfaces. Hence, the correct option is (C).

Quick Tip to Solve: Follow each terrace and recess around to the hidden side, then add the underside once. Count faces, not the visible edge strokes.

60. Find the total number of surfaces of the object given below in the problem figure. [4 marks]



(A) 15

(B) 16

(C) 14

(D) 13

Correct Answer: (A) 15

Solution:

Concept:

- A surface is a distinct planar face of the solid, rather than an edge or a corner. Faces that are hidden in the isometric view, including the underside, must also be counted.
- Count by orientation and level: horizontal terraces, vertical boundary faces, and any inclined faces. A change of height or a genuine fold separates faces; a single continuous coplanar region is counted once.

Step 1: Separate the horizontal regions Inspect the object from its lowest level upward. Identify the small high rear platform, the middle platform and the two separate lower terraces. Count a connected

planar terrace once, even when its outline has a notch or several corners. Do not count the black boundary lines themselves as surfaces, and do not split a continuous side merely because an edge of another platform ends against it.

Step 2: Complete the boundary and include hidden faces The large sloping right-hand roof is one inclined surface. Its neighbouring vertical step face remains a separate surface, and the lowest front faces continue underneath the projecting terraces. Continue the count around the rear and underside of the solid; a face need not be visible in the given view to belong to its boundary. Sorting the boundary this way gives four exposed horizontal regions, nine vertical faces, one inclined face and one underside. Internal contacts between joined parts are excluded, because they are not exposed surfaces of the completed object.

Step 3: Add the disjoint face groups The groups count different portions of the boundary, so none is counted twice. Their sum is

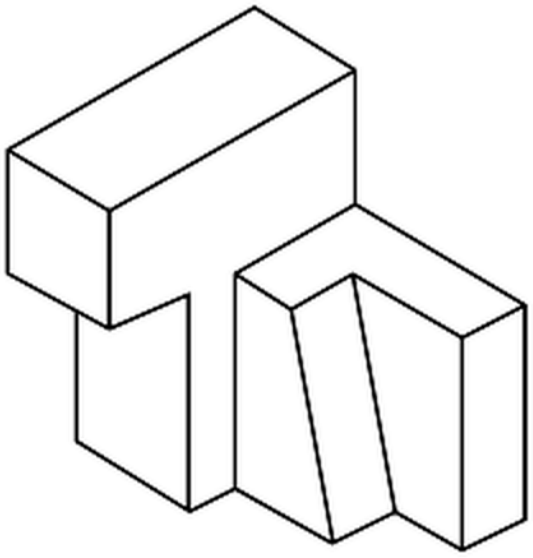
$$4 + 9 + 1 + 1 = 15.$$

The other offered totals, 16, 14, 13, do not account for the complete boundary: a smaller count omits a terrace, recess wall or hidden face, while a larger count splits a continuous face or counts an internal join. The requested total is therefore 15.

Step 4: Conclusion The object has 15 surfaces. Hence, the correct option is (A).

Quick Tip to Solve: Follow each terrace and recess around to the hidden side, then add the underside once. Count faces, not the visible edge strokes.

61. Directions : (For Q. 56 to 61). Find out the total number of surfaces of the object, given below in the problem figure. [4 marks]



(A) 13

(B) 12

(C) 11

(D) 10

Correct Answer: (A) 13

Solution:

Concept:

- A surface is a maximal connected plane face on the exterior of the object. An outline edge or a line separating two different planes is not an additional face.
- The total includes faces hidden behind or beneath the solid. Count visible faces first and then complete the exterior boundary; do not count an internal contact surface.

Step 1: Separate the visible plane faces Begin with the long upper bar. Its upper face and its left end face are distinct planes. The broad vertical face beneath its front edge continues into the central downward part and is counted as one face, even though its outline has a recess. The exposed vertical face on the left of that downward part supplies another face. Next move around the right-hand projection: identify its upper bent plane, the vertical face next to the central leg, the inclined central face, the inner vertical face of the right arm, and the right end face. These give nine visible exterior faces altogether. Count each connected plane once rather than treating every quadrilateral in the perspective drawing as a separate object.

Step 2: Include the exterior faces out of sight Now complete the back and underside of the solid. Following the boundary behind the visible faces leaves four additional exterior plane faces. The planes closing the solid on its far side and below must be included, although their edges are hidden in this view. Shared internal joins contribute no exterior surface. Consequently, the complete count is

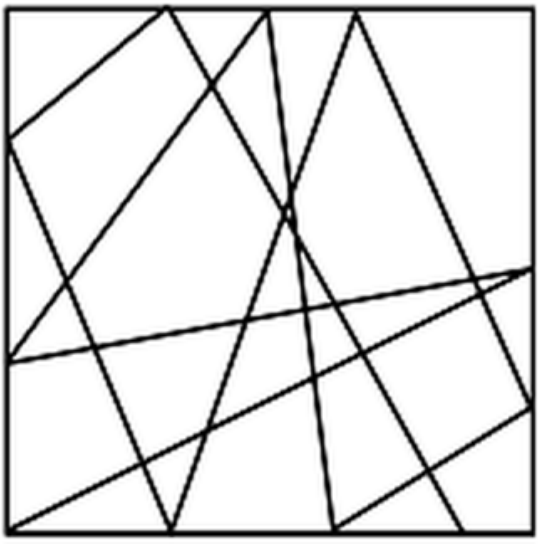
$$N = 9 + 4 = 13.$$

The values 12, 11 and 10 each miss one or more of these closing faces. Counting only the most prominent front faces therefore underestimates the total.

Step 3: Conclusion The object has 13 exterior surfaces. Hence, the correct option is (A).

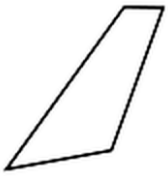
Quick Tip to Solve: Number the visible planes first, then follow the unseen back and bottom boundary. A recess changes the outline of a plane without necessarily creating another face.

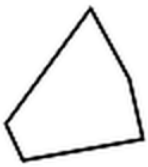
62. Directions : (For Q. 62 and 63). One of the following answer figures is hidden in the problem figure, in the same size and direction. Select, which one is correct ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- An embedded figure must use line segments already present in the larger diagram. Extra crossing lines can be ignored, but the required outline cannot be rotated, reflected or stretched.
- Compare the directions of successive edges and the relative lengths between corners. A similar-looking outline with one wrong corner is not the same figure.

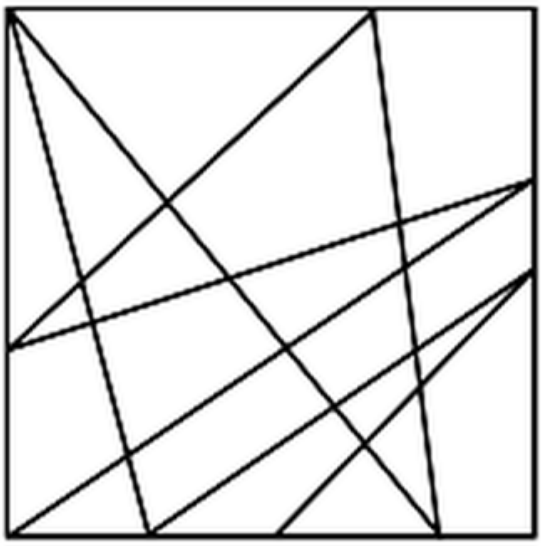
Step 1: Trace the quadrilateral inside the problem figure Inspect the lower central part of the square. Two long lines run shallowly upwards from left to right: one begins at the left edge below its midpoint, and the other begins at the bottom-left corner. Between them lie two steep lines, one rising towards the top edge on the right of centre and the other descending towards the bottom edge on the right of centre. Their four intersections outline the quadrilateral shown in (A). Its upper edge is short and only slightly inclined, its left edge rises steeply to the right, and its lower edge rises more noticeably to the right. The right boundary is steep and leans slightly the other way.

Step 2: Check the other outlines without changing their orientation Follow this four-sided boundary continuously, ignoring the surplus strokes passing through it. The corners and their order agree with (A), so no added segment or turn is required. Option (B) has a sharp high apex and a different arrangement of its long sides; that boundary cannot be traced in the same direction and size here. Option (C) is a much more elongated quadrilateral, so its top-to-bottom separation and edge directions do not fit the traced region. Option (D) has an additional corner: the required five-sided boundary does not match this four-sided outline. Rotation or reflection to improve those comparisons would violate the instruction.

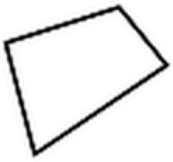
Step 3: Conclusion The answer figure hidden in the problem figure in the given size and direction is (A). Hence, the correct option is (A).

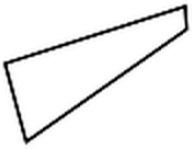
Quick Tip to Solve: Use the two shallow crossing lines in the lower half as the top and bottom edges, then close the shape with the two steep transversals.

63. Directions : (For Q. 62 and 63). One of the following answer figures is hidden in the problem figure, in the same size and direction. Select, which one is correct ? [4 marks]

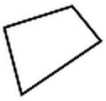


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- For an embedded figure, every side must coincide with an existing straight segment of the problem figure. Intersections along a side do not prevent that side from belonging to the figure.
- The outline must preserve its size, its handedness and the direction of every edge. Test the whole closed boundary rather than a single attractive triangle.

Step 1: Locate the four sides of the matching outline Look at the central-left portion of the square. Two lines issue from the upper-left corner: one descends steeply to the bottom edge near the left, while the other descends diagonally towards the bottom edge on the right. These provide the left and right sloping boundaries of the required quadrilateral. A shallow rising line running from the left edge to the upper part of the right edge cuts both of them and gives the upper side. The rising diagonal from the bottom-left corner towards the middle of the right edge cuts them again and gives

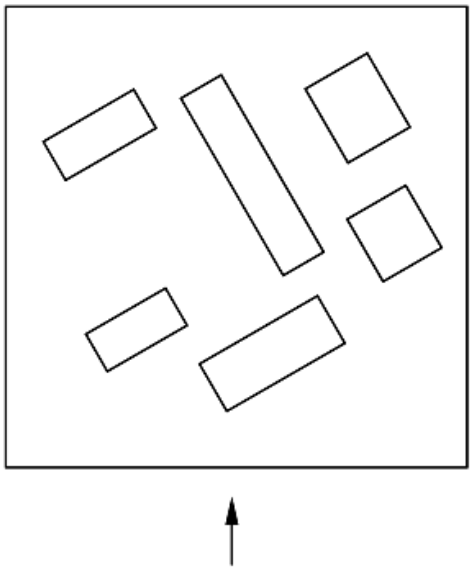
the lower side. The four intersections form exactly the outline in (B).

Step 2: Compare the shape with all answer figures Trace the four corners in order. The upper side rises gently to the right, the right side slopes down to the right, the lower side returns downwards to the left, and the left side closes steeply upwards. These directions and proportions match (B) without moving or turning it. Option (A) is triangular and lacks the fourth boundary turn. Option (C) is a long narrow outline whose two right-hand corners are close together; the necessary pair of nearly parallel long edges is not the traced figure. Option (D) has a different left-to-right taper and its short edges meet at different angles. A superficial overlap of one side is insufficient for any of these alternatives.

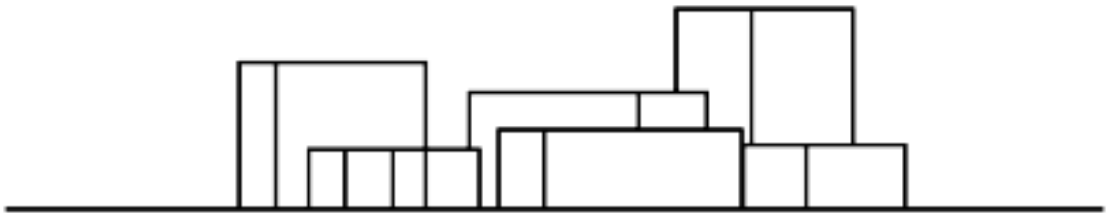
Step 3: Conclusion The embedded figure is the quadrilateral in (B). Hence, the correct option is (B).

Quick Tip to Solve: Start with the two diagonals from the upper-left corner; their intersections with the two rising cross-lines locate all four vertices of the correct outline.

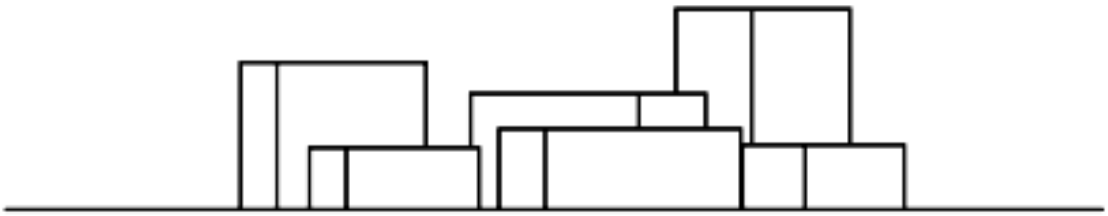
64. Directions : (For Q. 64 and 65). The problem figure shows the top view of objects. Looking in the direction of arrow, identify the correct elevation, from amongst the answer figures. [4 marks]



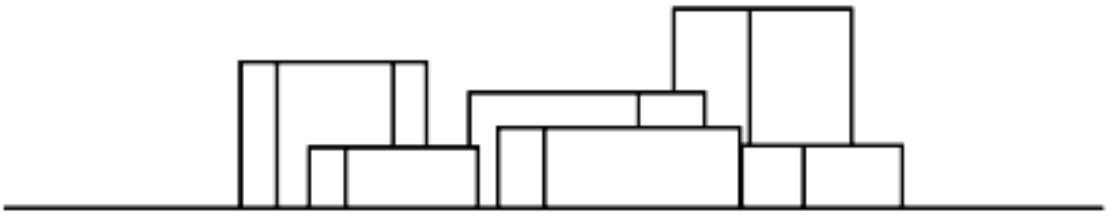
(A)



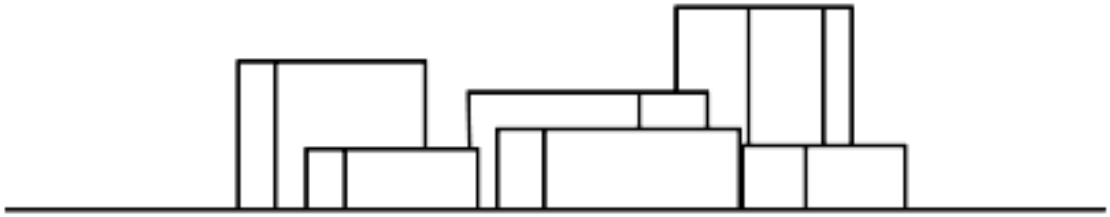
(B)



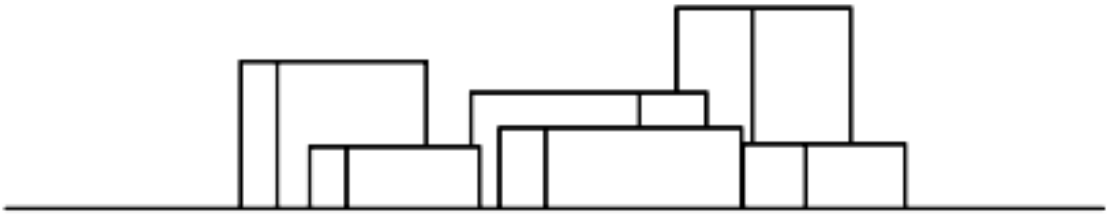
(C)



(D)



Correct Answer: (B)



Solution:

Concept:

- An elevation in the arrow direction is an orthographic view. Positions across the page remain left to right, while distance along the arrow becomes depth and is suppressed.
- A nearer solid hides edges of a farther solid over their common projected width. Only an exposed change of face or an actual visible boundary produces an internal vertical line.

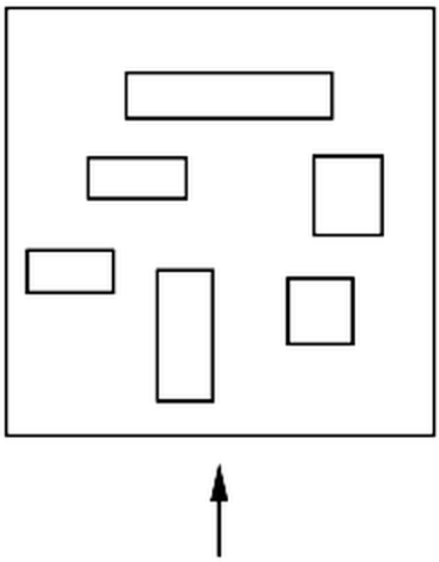
Step 1: Project the objects in the arrow direction The arrow points upward, so observe from the bottom of the plan. Retain each object's left and right limits, and compare which footprint is nearer wherever two projected widths overlap. The small rectangle towards the lower left stands in front of the left-hand object. The long lower rectangle similarly masks part of the middle object, and the small rectangle on the right is in front of the tall right-hand object. The rotated footprints also identify the visible vertical corner of each prism: two visible side faces meet there, but the far edges hidden behind a front face must not be added.

Step 2: Use the internal edges to distinguish the options The broad silhouette is nearly the same in all four choices, so it does not decide the answer. In (B), the left low object has one visible corner line near its left end; the tall object behind it also has its corner near the left. The central foreground block has one corresponding division, and the tall right object has a single visible corner at the position set by its rotated footprint. These are consistent with the nearer and farther positions in the plan. Option (A) inserts an extra vertical division in the low left-hand foreground block. Option (C) adds an unnecessary vertical line in the upper left-hand block, and (D) adds one in the upper right-hand block. Those extra strokes would expose edges that the given footprints do not show from the arrow direction.

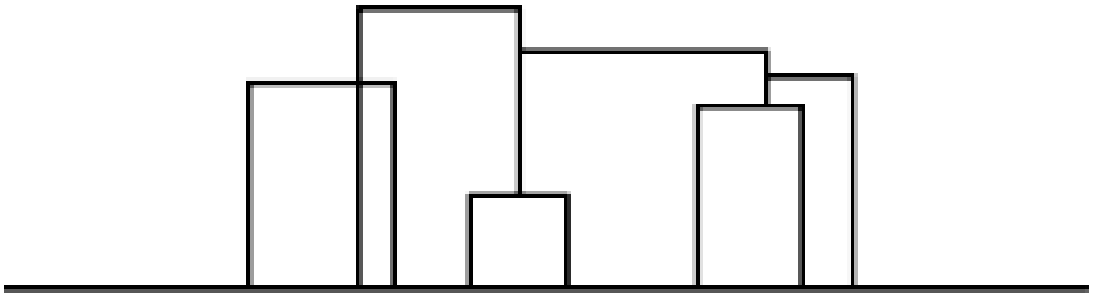
Step 3: Conclusion The correct elevation is (B). Hence, the correct option is (B).

Quick Tip to Solve: When the outside profiles look alike, examine the extra vertical strokes: a hidden rear edge must not appear through an opaque front face.

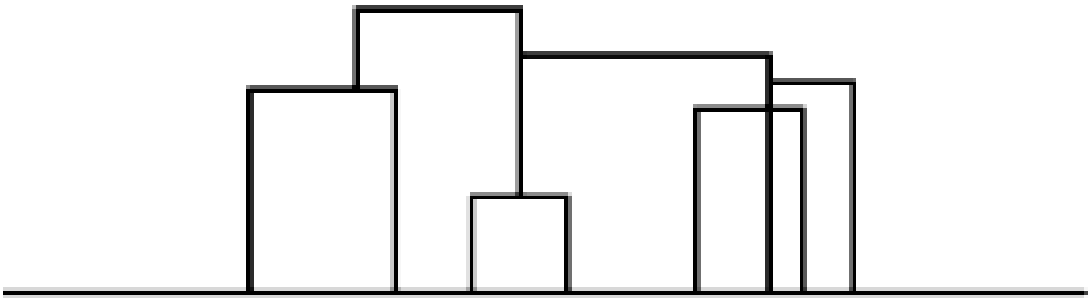
65. Directions : (For Q. 64 and 65). The problem figure shows the top view of objects. Looking in the direction of arrow, identify the correct elevation, from amongst the answer figures. [4 marks]



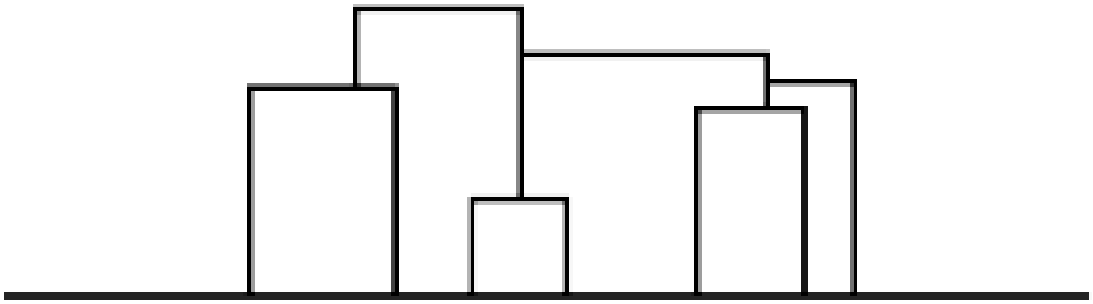
(A)



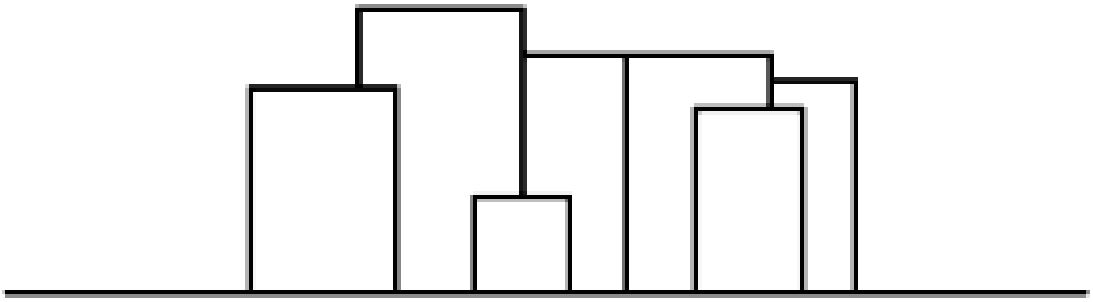
(B)



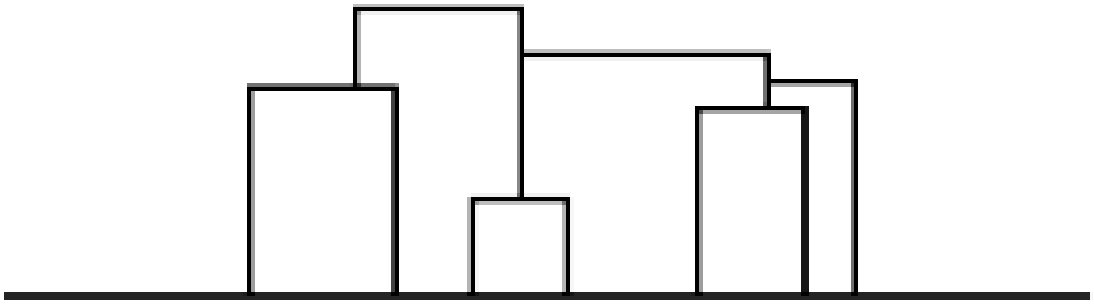
(C)



(D)



Correct Answer: (C)



Solution:

Concept:

- Viewing along the upward arrow means observing from the bottom of the top-view square. Objects nearer the bottom are in front of objects farther up.
- An elevation preserves horizontal position and width. Where projected intervals overlap, the nearer object conceals the portion of a farther vertical edge behind it.

Step 1: Order the footprints from front to back The narrow upright rectangle near the bottom centre is a foreground object. The small square to its right is also in front of the right-hand rectangle, while the lower-left rectangle lies in front of the left-hand rectangle farther up. The long horizontal rectangle at the top is behind these objects. First align their left and right limits vertically in the viewing direction. The low central object therefore interrupts the view of the tall rear block over its own width; the right foreground square interrupts the lower part of the object behind it. This ordering determines which vertical boundaries remain exposed.

Step 2: Remove the lines concealed by nearer objects The correct view has a plain left foreground

face, a tall rear block rising behind the small central foreground object, and the right foreground face covering the lower portion of the rear right edge. Option (C) respects all three visibility conditions. Option (A) carries an extra vertical division through the left-hand foreground region, although that part of the rear boundary is hidden. Option (B) allows a rear edge to remain visible in the right foreground object. Option (D) introduces an additional vertical line in the upper rear region that does not correspond to a visible front-facing corner in this unrotated plan. These are visibility errors rather than differences in the overall silhouette. The plain, uninterrupted faces in (C) are therefore decisive.

Step 3: Conclusion The elevation consistent with the upward viewing arrow is (C). Hence, the correct option is (C).

Quick Tip to Solve: Mark the three nearest footprints first. In the elevation, erase every rear edge covered by one of their projected front faces.

66. Who among the following is not an architect ? [4 marks]

(A) Zaha Hadid

(B) M.F. Hussain

(C) Hafiz Contractor

(D) Raj Rewal

Correct Answer: (B) M.F. Hussain

Solution:

Concept:

- Architecture concerns the design of buildings and built spaces. An architect's professional work must be distinguished from painting and other visual arts.
- For a negative identification question, first confirm the three members of the named profession, then select the person whose principal creative field is different.

Step 1: Identify the architects among the names Zaha Hadid was an architect associated with expressive, flowing architectural forms and the design of major cultural and public buildings. Hafiz Contractor is an Indian architect known for architectural practice across residential, commercial and other building projects. Raj Rewal is also an Indian architect, recognised for institutional and public architecture. Thus (A), (C) and (D) all belong to the profession named in the question. A distinctive design style, an international practice or work in India does not change their classification as architects.

Step 2: Identify the person from a different art form M. F. Hussain, more commonly spelled M. F. Husain, is known as a painter and a major figure in modern Indian art. His work belongs primarily to painting rather than professional architectural design. The question asks who is not an architect, so it is this difference of artistic profession that decides the answer. It would be incorrect to reject Hadid merely because she was not Indian, since no nationality restriction is given. It would also be incorrect to choose Contractor or Rewal on the basis of the kinds of buildings they designed: both are architects. The negative word in the stem therefore singles out the painter among three architects.

Step 3: Conclusion M. F. Hussain is the painter among the listed names and is not an architect.

Hence, the correct option is (B).

Quick Tip to Solve: For architecture-awareness lists, associate each name with a profession before considering nationality or design style; here Husain is the painter.

67. Fatehpur Sikri was built by : [4 marks]

(A) Jahangir

(B) Akbar

(C) Humayun

(D) Shah Jahan

Correct Answer: (B) Akbar

Solution:

Concept:

- Fatehpur Sikri is a planned Mughal imperial city associated with Emperor Akbar. Identifying its patron is an architectural-history question, rather than a question about the ruler who later occupied another Mughal capital.
- The Mughal succession helps distinguish the options: Humayun preceded Akbar, while Jahangir and Shah Jahan came after him. A building or city must be matched to the reign in which it was commissioned.

Step 1: Identify the imperial patron Akbar developed Fatehpur Sikri near Agra as an imperial capital in the sixteenth century. Its major palace and court buildings belong to his reign. The name of the city is therefore associated with Akbar in the standard chronology of Mughal architecture.

Step 2: Distinguish the other rulers Humayun was Akbar's father and predecessor; he is not the founder of this imperial city. Jahangir was Akbar's successor, so selecting him would place the foundation too late. Shah Jahan belongs to the later phase of Mughal architecture associated especially with the Taj Mahal and Shahjahanabad, rather than the founding of Fatehpur Sikri.

Step 3: Match the fact to the options Option (B) names Akbar, the ruler responsible for building the imperial city. Options (A), (C) and (D) name other Mughal emperors but do not identify the patron of Fatehpur Sikri. The shared Mughal connection alone is not enough to make an option correct.

Step 4: Conclusion Fatehpur Sikri was built by Emperor Akbar. Hence, the correct option is (B).

Quick Tip to Solve: Associate Fatehpur Sikri with Akbar; separate that association from Shah Jahan and the Taj Mahal.

68. Which one of the following is a sound reflecting material ? [4 marks]

(A) Thermocol

(B) Jute cloth

(C) Glass

(D) Fabric

Correct Answer: (C) Glass

Solution:

Concept:

- Sound incident on a surface can be reflected, absorbed or transmitted. A hard, smooth and relatively nonporous surface generally reflects sound more strongly than a soft, porous or fibrous finish.
- For architectural material selection, compare the surface character of the listed materials. The question asks for a sound-reflecting material, so a material used for acoustic absorption is the wrong category.

Step 1: Classify the candidate surfaces Glass presents a hard, smooth surface. It does not provide the open, fibrous structure that traps air and dissipates much of the incident sound energy as heat. It is consequently the conventional reflecting surface among the four listed choices.

Step 2: Eliminate the soft and porous choices Jute cloth and fabric are fibrous materials; their interstices and flexible fibres favour sound absorption compared with a bare glass surface. Thermocol is a lightweight cellular material, rather than the hard, dense, smooth finish sought by this question. Its acoustic behaviour depends on thickness and installation, but it is not the best reflecting choice here.

Step 3: Select the required acoustic property The contrast is between a hard reflective surface and the softer or cellular alternatives. Glass can contribute to reflections and reverberation in a room; fabric or jute treatments are instead used to soften reflected sound. Thus option (C) matches the property stated in the question, while (A), (B) and (D) do not provide the intended example.

Step 4: Conclusion Glass is the sound-reflecting material in this list. Hence, the correct option is (C).

Quick Tip to Solve: For a basic acoustics MCQ, first compare hard, smooth finishes with porous or fibrous finishes.

69. Buckingham Palace is located in : [4 marks]

(A) Paris

(B) London

(C) Geneva

(D) Singapore

Correct Answer: (B) London

Solution:

Concept:

- A landmark-location question requires the city containing the named building. Buckingham Palace is the British royal palace associated with London.
- Distinguish the identity of the landmark from other famous buildings in the listed cities. The fact that every option is a major city does not establish any connection with Buckingham Palace.

Step 1: Recall the landmark and its city Buckingham Palace stands in London, in the United Kingdom. It is widely identified with the British monarchy and with royal ceremonial life in the British capital. This direct building-city association supplies the answer without any geographical calculation.

Step 2: Check the competing city names Paris is the capital of France and is associated with French landmarks, not Buckingham Palace. Geneva is a Swiss city and does not contain the British royal palace. Singapore is a separate city-state in Southeast Asia; it is also unrelated to the location asked for. These are distinct places rather than alternative names for London.

Step 3: Match the location to the printed order London appears as option (B). The options (A), (C) and (D) respectively identify Paris, Geneva and Singapore, so none can replace London in the statement. Keeping the country and city linked prevents confusion between a familiar landmark and an equally familiar but unrelated world city.

Step 4: Conclusion Buckingham Palace is located in London. Hence, the correct option is (B).

Quick Tip to Solve: Link the pair Buckingham Palace–London before inspecting other city names; then select its printed letter.

70. What secondary colour is obtained by mixing blue and red colours ? [4 marks]

(A) Pink

(B) Purple

(C) Orange

(D) Brown

Correct Answer: (B) Purple

Solution:

Concept:

- In the traditional pigment colour wheel used in elementary art and design, red, blue and yellow are primary colours. Mixing two primaries gives a secondary colour.

- The secondary pigment combinations are red with blue giving purple, red with yellow giving orange, and blue with yellow giving green. This question uses colour mixing in that art-and-design sense.

Step 1: Choose the appropriate colour model The question asks for a secondary colour from mixing blue and red. In the conventional painting colour wheel, those two are primary pigments, and their mixture lies in the violet or purple region. It is the pigment colour relationship used in basic architectural aptitude questions.

Step 2: Compare the listed secondary colours Purple is the named result of the red-blue mixture and appears in option (B). Orange is a secondary colour too, but it requires red and yellow rather than red and blue. Therefore merely recognising a secondary colour is insufficient; its component primaries must also match the question.

Step 3: Rule out the remaining alternatives Pink is normally produced by lightening red with white, not by mixing red with blue. Brown is not the pure secondary red-blue mixture on the traditional colour wheel; it is generally obtained by more complex or complementary pigment mixtures. Hence (A), (C) and (D) each fail the specified pair of input colours.

Step 4: Conclusion Mixing blue and red pigments gives purple. Hence, the correct option is (B).

Quick Tip to Solve: Remember the pigment pairs: red-blue gives purple, red-yellow gives orange, and blue-yellow gives green.

71. Lotus Temple in Delhi was built by : [4 marks]

(A) Jews

(B) Jains

(C) Bahais

(D) Muslims

Correct Answer: (C) Bahais

Solution:

Concept:

- The Lotus Temple in Delhi is a Baha'i House of Worship. Its lotus-shaped architecture identifies a building belonging to the Baha'i faith.
- The religious affiliation of a building is different from the nationality of its architect or the identities of individual construction workers. Here the choices name religious communities, so the institutional affiliation is what is being tested.

Step 1: Identify the building named The Lotus Temple is the well-known lotus-shaped place of worship in Delhi. It is associated with the Baha'i community and is described as a Baha'i House of Worship. This is the relevant fact for interpreting the question's phrase "built by".

Step 2: Read the community names carefully The printed word Bahais in option (C) refers to followers of the Baha'i faith. Jews are associated with Judaism, Jains with Jainism, and Muslims with Islam. Although all four are religious communities, only the Baha'i community has the required association

with this particular Delhi building.

Step 3: Separate open access from affiliation The temple welcomes visitors of different backgrounds, but that openness does not change its identity as a Baha'i House of Worship. It therefore would be incorrect to choose another community simply because its members may visit the building. Among the given alternatives, (C) states the correct institutional association and the other three do not.

Step 4: Conclusion The Lotus Temple in Delhi is a Baha'i House of Worship, associated with the Bahais. Hence, the correct option is (C).

Quick Tip to Solve: Use the landmark pair Lotus Temple–Baha'i House of Worship; do not confuse visitor access with religious affiliation.

72. Which one of the following material cannot be used in its original form for construction of walls ? [4 marks]

(A) Fly ash

(B) Basalt

(C) Laterite

(D) Granite

Correct Answer: (A) Fly ash

Solution:

Concept:

- A wall material must form stable units or a coherent mass capable of being laid and bonded. Natural building stones can be cut or dressed into masonry blocks, whereas loose powder cannot simply be laid as a wall.
- Fly ash is a fine particulate residue. It is useful in construction after incorporation into manufactured bricks, cementitious mixtures or other bound products; that processed use differs from use in its original loose form.

Step 1: Examine the original form of fly ash Fly ash consists of fine particles rather than self-supporting masonry units. In its original form it lacks the solid block shape and cohesion needed to build a stable wall directly. It must first be combined with appropriate binders and processed, for example into fly-ash bricks, before it can function as wall construction material.

Step 2: Compare the three natural stones Basalt, laterite and granite occur as solid natural materials that can supply building stone. They may be cut, quarried or dressed into suitable masonry units while remaining stone, so their use does not require transformation of loose powder into an entirely new bound product. Laterite in particular is commonly cut into blocks for masonry.

Step 3: Apply the qualification in the question The decisive wording is "in its original form". Fly ash is certainly a construction ingredient, but that fact does not mean loose ash can be stacked or bonded directly as a conventional wall. Option (A) is therefore the exception. The other options name natural stones capable of use as masonry material, subject to ordinary preparation and suitability checks.

Step 4: Conclusion Fly ash cannot be used in its original loose form to construct a wall; it must first

be made into a suitable bound product. Hence, the correct option is (A).

Quick Tip to Solve: When a material question says "original form", distinguish loose ingredients from solid masonry units.

73. Green architecture is promoted these days because : [4 marks]

(A) It costs less initially

(B) It is environment friendly

(C) It lasts longer

(D) Green is a good colour

Correct Answer: (B) It is environment friendly

Solution:

Concept:

- Green architecture reduces a building's adverse environmental effects throughout its life, from construction and occupation to eventual reuse or disposal.
- Its principal concerns include efficient use of energy and water, responsible selection of materials, reduced waste and a healthy indoor environment.

Step 1: Identify the purpose of green design A building uses resources both when it is built and while people occupy it. Green design seeks to reduce these demands through measures such as daylighting, natural ventilation where suitable, shading, water conservation and efficient equipment. Materials may also be selected to reduce environmental damage and waste. These measures explain why the approach is promoted: it aims to make buildings more environment friendly. The word green therefore describes an environmental approach to design, rather than the paint colour of the building.

Step 2: Compare the proposed reasons Option (B) states this environmental objective directly. Option (A) is not a general rule: some green measures save money immediately, while others need a larger initial investment and recover it through lower operating costs. Option (C) is also not a defining condition; durability depends on materials, detailing, construction and maintenance, and a conventional building can be long lasting. Option (D) confuses the name of the approach with a visual colour preference. A green building need not have a green exterior at all.

Step 3: Conclusion Green architecture is promoted because it is environment friendly, conserving resources and reducing the environmental impact of buildings. Hence, the correct option is (B).

Quick Tip to Solve: Link green architecture to energy, water, materials and environmental impact; do not interpret green as a required surface colour.

74. What is texture ? [4 marks]

(A) A solid colour

(B) A type of shape

(C) Lines drawn in one colour

(D) The way a surface looks and feels

Correct Answer: (D) The way a surface looks and feels

Solution:

Concept:

- Texture is the perceived surface quality of an object or material, such as smoothness, roughness, graininess or softness.
- Actual texture can be felt by touch; visual texture is suggested to the eye by patterns, marks, shading or the appearance of a material.

Step 1: Relate texture to the surface Consider polished stone and rough brick. Their overall shapes can be similar and their colours can even be alike, yet their surfaces look and feel different. That surface difference is texture. A textured surface can influence how light is reflected, how shadows appear in small irregularities and how the material feels to the hand. In a drawing, the artist can suggest the same quality with repeated marks or tonal variation even though the paper itself remains smooth. Thus the idea includes both visual appearance and tactile sensation.

Step 2: Distinguish texture from other design elements Option (D), the way a surface looks and feels, captures this meaning. A solid colour in option (A) describes hue or colour treatment and does not, by itself, identify roughness or smoothness. Option (B) concerns shape, which describes an outline or form rather than surface quality. Lines drawn in one colour, option (C), may be a technique for suggesting texture, but they are not its definition: lines can also describe an edge, a boundary or direction. The definition must apply to both real materials and their visual representation.

Step 3: Conclusion Texture is the way a surface looks and feels, including its visual and tactile qualities. Hence, the correct option is (D).

Quick Tip to Solve: When distinguishing shape, colour and texture, ask whether the description concerns the outline, the hue or the surface quality.

75. Which one of the following is not an earthquake resistant structure ? [4 marks]

(A) RCC framed structure

(B) Load bearing brick walls building

(C) Steel framed building

(D) Timber framed building

Correct Answer: No structural material or system listed is inherently guaranteed to be earthquake resistant; the unqualified question has no unique technical answer.

Solution:

Concept:

- Earthquake resistance depends on structural configuration, load paths, connections, ductility, foundations and appropriate seismic detailing, not solely on the name of a material.
- Unreinforced masonry is usually vulnerable because it has low tensile strength and limited ductility; properly reinforced and tied masonry can nevertheless be designed for seismic resistance.

Step 1: Examine the commonly intended comparison A conventional unreinforced load-bearing brick building is usually the vulnerable example among these choices. Earthquake shaking produces horizontal inertia forces and can crack brittle masonry or separate poorly connected walls and roofs. This makes option (B) the likely intended classroom comparison. However, the option only says load-bearing brick walls; it does not specify unreinforced walls, deficient connections or absence of seismic bands. Reinforcement, confinement, ties and suitable planning can improve a masonry building's seismic behaviour substantially. It cannot be ruled out solely because its walls carry loads.

Step 2: Check whether the other systems are automatically safe RCC frames require suitable reinforcement and ductile detailing; an inadequately detailed frame can fail during shaking. Steel frames also need an appropriate lateral-force-resisting system and reliable joints. Timber frames are comparatively light and can be ductile, but weak connections or poor bracing can still make them unsafe. Thus options (A), (C) and (D) are not unconditional guarantees of resistance either. Without the design, detailing and construction conditions, the wording does not establish a unique structure that is or is not earthquake resistant.

Step 3: Conclusion The likely intended example is an ordinary unreinforced load-bearing brick building, corresponding to (B), but that qualification is absent. As printed, there is no unique technically defensible answer. The official answer key dropped this question and awarded bonus credit to all candidates.

Quick Tip to Solve: Distinguish a material from its seismic design: check reinforcement, lateral load paths, ductility and connections before judging earthquake resistance.

76. Which one of the following is an odd match ? [4 marks]

(A) Deforestation - Climate change

(B) Ozone layer - UV rays

(C) Shrinking Polar Caps - Earthquake

(D) Tsunami - Oceanic Earthquake

Correct Answer: (C) Shrinking Polar Caps - Earthquake

Solution:

Concept:

- An odd-match question asks which pair lacks the usual direct relationship shared by the other pairs.
- Climate processes concern long-term atmospheric and thermal changes, while earthquakes primarily result from sudden movement along faults in the Earth's crust.

Step 1: Verify the three related pairs Deforestation contributes to climate change by removing vegetation that absorbs carbon dioxide and, in many cases, releasing stored carbon through burning or decay. The ozone layer is related to ultraviolet rays because stratospheric ozone absorbs much of the Sun's harmful ultraviolet radiation. A tsunami can be generated by an oceanic earthquake when movement of the sea floor suddenly displaces a large volume of seawater. These statements establish a clear relationship for options (A), (B) and (D); each pairs a phenomenon with an associated cause, effect or protective function.

Step 2: Identify the pair with the wrong association Shrinking polar ice caps are associated chiefly with warming and the resulting changes in melting and accumulation of ice. An earthquake is a sudden release of elastic strain energy in the Earth's crust and is not the usual cause of the long-term shrinkage of the polar caps. Therefore option (C) pairs two phenomena without the ordinary explanatory connection used in the other options. The task is to identify the mismatched association, rather than to find two words belonging to the same broad subject of the environment.

Step 3: Conclusion Shrinking Polar Caps–Earthquake is the odd match; polar ice loss is associated with warming rather than earthquakes. Hence, the correct option is (C).

Quick Tip to Solve: Test each pair by stating its direct connection in one sentence; the pair requiring an unrelated cause is the odd match.

77. Why do large industrial buildings have high located glazing on the North side ? [4 marks]

(A) To get bright sunlight throughout the day.

(B) To stop the workers from looking outside.

(C) To get uniform shadow - less light through the day.

(D) Because the sun stays on the North side throughout the day.

Correct Answer: (C) To get uniform shadow - less light through the day.

Solution:

Concept:

- Industrial daylighting aims to provide reasonably uniform illumination of work surfaces while limiting glare, harsh shadows and unwanted solar heat gain.
- North-light glazing in the usual Indian northern-hemisphere design context admits predominantly diffuse sky light, rather than strong direct sunshine for most of the working day.

Step 1: Explain the benefit of high north glazing High glazing allows daylight to reach farther into a large industrial work space. When the glazed face is oriented north in the conventional north-light arrangement, it receives useful diffuse light from the sky with less exposure to the intense direct rays associated with other orientations. Diffuse illumination reduces sharp contrasts and the hard, moving shadows that can interfere with careful work. This is particularly useful in workshops and factories where consistent visibility is more valuable than patches of bright sunshine on the working floor.

Step 2: Eliminate the alternative explanations Option (C) expresses the design objective as uniform, shadow-less light through the day. Here shadow-less means relatively soft and even illumination, not a literal absence of all shadows. Option (A) incorrectly identifies bright direct sunlight as the goal; that can cause glare and changing contrasts. Option (B) does not explain the choice of north orientation: raising a window might limit views regardless of its compass direction. Option (D) is false, since the Sun does not stay on the north side throughout the day. Solar position changes with time, latitude and season.

Step 3: Conclusion High north-side glazing is used to obtain relatively uniform, diffuse and soft illumination of the industrial interior. Hence, the correct option is (C).

Quick Tip to Solve: For north-light factory roofs, remember diffuse daylight and reduced glare; maximum direct sunshine is not the design objective.

78. Which one of the following is an odd match ? [4 marks]

(A) Hot and Humid - Chennai

(B) Cold and Dry - Ladakh

(C) Temperate - Shimla

(D) Hot and Dry - Jaisalmer

Correct Answer: (C) Temperate - Shimla

Solution:

Concept:

- Architectural climate classification groups places according to conditions affecting building design, including temperature, humidity, rainfall and solar exposure.
- In the standard Indian building-climate examples, Chennai represents warm or hot humid conditions, Ladakh cold and dry conditions, Jaisalmer hot and dry conditions, and Shimla cold and cloudy conditions.

Step 1: Check the characteristic climate examples Chennai is a coastal city with generally high temperatures and high humidity, so its pairing with hot and humid is appropriate. Ladakh is a high-altitude region with low temperatures and low precipitation, making cold and dry the appropriate association. Jaisalmer lies in the arid desert region of Rajasthan, where high summer temperatures and low humidity make hot and dry an appropriate description. These three options therefore agree with the standard climatic examples used in architectural design questions.

Step 2: Locate the incorrect building-climate pairing Shimla is a Himalayan hill station used as an example of the cold and cloudy category in the Indian building-climate classification. It is consequently the mismatched example when paired with temperate in option (C). The term temperate can be used broadly in everyday geographical descriptions of hill climates, but the comparison here uses the architectural categories shown by the other city pairs. In that classification, a moderate or temperate example is distinguished from a cold hill station. This makes the Shimla pairing the odd one within the question's common scheme.

Step 3: Conclusion Temperate–Shimla is the odd match in the standard Indian architectural climate classification; Shimla belongs to the cold and cloudy category. Hence, the correct option is (C).

Quick Tip to Solve: Learn city examples with their architectural climate groups; for Shimla use cold and cloudy when comparing these standard design categories.

79. Which one of the following is not a matching set ? [4 marks]

(A) Sundarbans - Mangroves

(B) Varanasi - Ghats

(C) Jaipur - Canals

(D) Udaipur - Lakes

Correct Answer: (C) Jaipur - Canals

Solution:

Concept:

- A geographical matching question pairs a place with a characteristic natural feature or a distinctive part of its built environment. The correct association must describe the particular place named, rather than a feature found somewhere in the same country.
- For a negative question, identify the three established associations first. The remaining pair is the requested mismatch; the word 'not' reverses the usual selection rule.

Step 1: Verify the natural landscape associations The Sundarbans is a tidal delta landscape associated with mangrove forests. Its vegetation is adapted to saline or brackish tidal conditions, so Sundarbans–Mangroves is a matching pair. Udaipur is well known for its lakes, including Lake Pichola and Fateh Sagar. Udaipur–Lakes is therefore also a matching pair, and neither (A) nor (D) answers a question asking for the mismatch.

Step 2: Compare the two remaining city associations Varanasi is associated with the ghats along the River Ganga: the steps and riverfront spaces are a defining part of the city's setting. Thus (B) is a matching pair. Jaipur, the Pink City, is characteristically associated with its planned streets, historic architecture, palaces and forts. Canals are not the characteristic association that identifies Jaipur in this set. Consequently the mismatch is Jaipur–Canals, rather than any of the three correctly paired places.

Step 3: Conclusion The pair Jaipur–Canals is not a matching set. Hence, the correct option is (C).

Quick Tip to Solve: Underline 'not' before comparing the pairs. Eliminate Sundarbans–mangroves, Varanasi–ghats and Udaipur–lakes as established associations, leaving Jaipur–canals.

80. Which one of the following is not a matching set ? [4 marks]

(A) San Francisco - Golden Gate Bridge

(B) Washington - White House

(C) Egypt - Mississippi River

(D) England - 10 Downing Street

Correct Answer: (C) Egypt - Mississippi River

Solution:

Concept:

- A landmark-location pair is correct when the named structure, institution or geographical feature belongs to the stated city or country. Distinguish a country's own river from a famous river situated on another continent.
- The question asks for the pair that is not matching. A correct landmark association is therefore eliminated rather than selected; the mismatch must fail the geographical-location test.

Step 1: Check the architectural landmark pairs The Golden Gate Bridge spans the Golden Gate strait at San Francisco, so San Francisco–Golden Gate Bridge is correctly associated. The White House is the residence and workplace of the President of the United States in Washington, D.C., so Washington–White House is also correctly associated. Number 10 Downing Street is in London, England, and is associated with the British Prime Minister. Thus England–10 Downing Street is a matching pair as well. These checks eliminate (A), (B) and (D).

Step 2: Locate the river named in the remaining pair The Mississippi River is in North America and is a major river of the United States. It is not an Egyptian river. Egypt is instead strongly associated with the River Nile, which runs through its inhabited valley and delta. The pair Egypt–Mississippi River therefore joins a country to a river on a different continent and fails the location test. This is the sole incorrect association among the four supplied choices.

Step 3: Conclusion Egypt–Mississippi River is the mismatched pair; the Mississippi is in North America. Hence, the correct option is (C).

Quick Tip to Solve: For river-country pairs, check the continent first. The Mississippi belongs to North America, whereas Egypt's defining river is the Nile in Africa.

Drawing Test (70 marks)

81(a). Draw a rectangular frame of size 140 mm $\times$ 210 mm in the space provided for answering this question. In this frame, compose an aesthetic 3 - dimensional composition, appropriate to the size of the frame, comprising cubes, cones and cylinders. There is no restriction of numbers, sizes, placement and direction of these solids in this frame. Colour your composition to make it visually exciting. [40 marks total]

Solution:

Concept:

- A three-dimensional composition needs identifiable cubes, cones and cylinders, a clear focal group, and a consistent view so the forms share the same space.
- Overlap, changes in apparent size, contact shadows and tonal contrast create depth. Light and colour must describe the solids rather than flatten their surfaces.

Step 1: Set out the frame and main group Draw the stated $140\,\text{mm} \times 210\,\text{mm}$ rectangle accurately. Use either orientation, leaving a modest clear margin inside it. Place a large cube a little off centre as the dominant form, a taller cylinder behind it and a smaller cone in front to one side. This arrangement is one valid design, since the question permits any number, size and direction of the three solid types. Let the group occupy most of the frame without touching its edges; balance the taller cylinder with the broader cube instead of distributing identical objects at equal intervals.

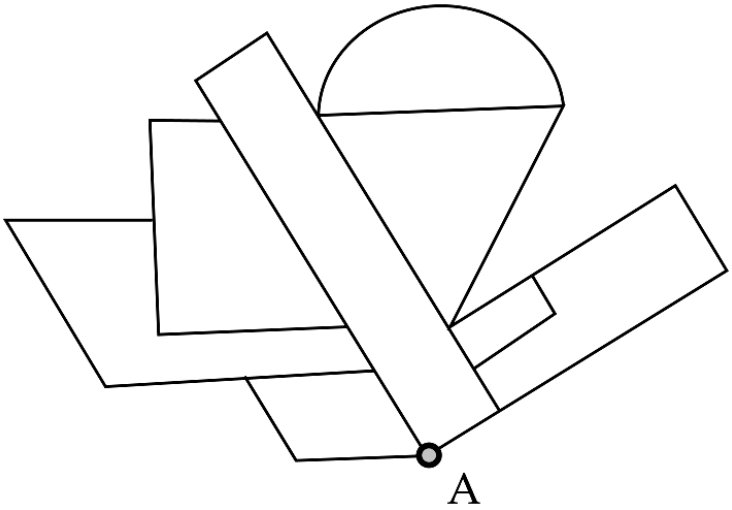
Step 2: Construct coherent volumes Establish an eye level and use a consistent two-point perspective for the cube: vertical edges remain vertical and each family of receding horizontal edges tends towards its own vanishing point. Show the cylinder top as an ellipse, align its side generators, and curve its lower visible rim consistently. Construct the cone on an elliptical base with its apex above the base centre. Overlap the cone slightly over the cube and the cube over part of the cylinder, keeping enough of every solid visible to identify it. Avoid accidental tangencies where unrelated edges merely touch.

Step 3: Apply colour and light Choose one light source, for example above and to the left. Give the cube a light top, middle-tone front and darker side. On the cylinder and cone, grade the colour across the curved surfaces instead of using arbitrary flat patches. Use a restrained warm orange for the focal cube, blue for the cylinder and a smaller yellow accent for the cone; repeat a little of each hue elsewhere to unite the group. Add connected cast shadows on the ground plane, darkest at contact, and reserve the brightest highlights. Finish with clean visible edges and reduce the weight of construction lines.

Step 4: Conclusion A suitable answer is an asymmetric, coloured group of a cube, cylinder and cone within the exact frame, with coherent perspective, deliberate overlaps and a single lighting direction. Other arrangements are equally valid if all three solid types remain recognisable and the composition is balanced and spatially convincing.

Quick Tip to Solve: Before colouring, check that every solid is readable in outline and that the overlaps create one connected group rather than three isolated objects.

81(b). Draw the graphic given below, such that it is rotated clockwise at an angle of 90 degrees about the point "A". Care should be taken to get the same sizes of all lines in the new rotated position.



Solution:

Concept:

- A clockwise quarter-turn about A is a rigid rotation: A stays fixed and every other point travels through the same angle while preserving its distance from A.
- With A as origin, x positive to the right and y positive upwards, the rotation is $(x, y) \mapsto (y, -x)$. It preserves line lengths, angles, the circular arc and the overlaps of the complete graphic.

Step 1: Locate the pivot and identify all features Mark A precisely at the centre of the small outlined pivot circle. Treat the entire visible graphic as one connected arrangement, including the long diagonal band ending at A, the sloping band extending to the right, the central triangular region with its curved cap, and the angular outlines extending to the left. Identify all visible corners, junctions and endpoints before beginning. Include the endpoints and highest point of the curved cap, not only the outer polygon corners. Preserve the source order of overlapping bands: the quarter-turn must not reveal lines that are hidden in the given picture.

Step 2: Rotate each construction point For each point P, join A to P lightly and measure AP. At A, turn that direction through 90° clockwise, then mark P prime at the same distance from A on the new ray. Repeat for every corner and junction; a point directly above A must move directly to its right, and a point directly left of A must move directly above it. These two tests prevent an anticlockwise result. Equivalently, if a point is x units right and y units above A, its rotated position is y units right and x units below A. Negative coordinates are handled with the same formula, so the rule applies to points in every quadrant.

Step 3: Reconstruct and verify the whole graphic Join corresponding rotated points in precisely the original connectivity, keeping each visible segment and gap. Transfer the curved cap by rotating its centre and endpoints, or by rotating several points along the original curve and joining them smoothly. Retain its radius and the straight chord. Rotate the small circle at A into itself and place the label A nearby without obscuring the pivot. Check several full edge lengths with dividers, compare parallel edges and right angles, and verify that AP equals AP prime for every transferred point. Do not rotate each component about its own centre or reflect the picture: the complete arrangement must undergo

one rotation about A.

Step 4: Conclusion The required result is the entire supplied graphic turned 90° clockwise about the fixed point A, with every edge, arc, relative overlap and length unchanged. The exact construction rule is $P(x, y) \mapsto P'(y, -x)$ in Cartesian coordinates centred at A.

Quick Tip to Solve: Check one point above A and one point left of A first: after a clockwise quarter-turn they must lie right of A and above A respectively.

82. Draw from memory a balloon seller, selling balloons to a group of small children. [30 marks]

Solution:

Concept:

- A memory drawing should communicate the specified action immediately: a balloon seller actively selling to a group of small children. Figure scale, gesture and interaction carry the narrative.
- Foreground overlap, a shared eye level and consistent ground contact give spatial unity. A clear focal group and a controlled tonal range prevent background details from competing with the activity.

Step 1: Arrange the focal action Choose a street-side view at approximately the eye level of an adult observer. Place the balloon seller slightly to one side of the centre, with a cluster of balloons rising above the group. Arrange four small children around the seller in an irregular shallow arc: one reaches up towards a balloon, another offers payment, and two wait while looking at the balloons. This is a valid model arrangement rather than a uniquely prescribed number. Leave room above the balloons and below the feet so the figures do not appear cramped against the frame. Use the tilted balloon strings and the children's gestures to lead the eye towards the exchange.

Step 2: Construct believable figures and balloons Begin each person with a light head, torso and limb framework. Make the children visibly shorter than the adult, with proportionately larger heads and varied heights. Bend elbows and shoulders naturally so the receiving hand, the seller's hand and the balloon string relate to one another. Place the feet on a shared ground plane, with overlaps distinguishing the nearer child from those behind. Draw several inflated balloons with rounded or oval forms, some overlapping, and gather their strings convincingly in the seller's hand. Keep the strings separate enough to read without turning the central area into a dark scribble.

Step 3: Develop setting and tone Suggest a pavement edge, a simple wall or a distant tree with sparse lighter lines; these provide context but must not hide the figures. Indicate one light direction and add short cast shadows under the people so they stand on the ground. Use stronger line and tonal contrast in the focal hands, faces and balloons, with lighter and less detailed background forms. Vary the clothing folds and expressions to show interest and movement rather than drawing a row of identical posed figures. Preserve a clear silhouette around the balloon cluster and finish by removing unnecessary construction lines.

Step 4: Conclusion A successful composition shows an adult balloon seller in an active exchange with several recognisably small children, supported by convincing gestures, balloon strings, proportion, overlap and ground shadows. The scene should read clearly as a sale, rather than a static group

portrait beside balloons.

Quick Tip to Solve: Establish the hand-to-hand exchange and the cluster of balloon strings before adding facial detail or background scenery; those features make the activity recognisable.

OR

82. Draw from memory a scene of a group of village women around a handpump with their pitcher-s/utensils for filling water.

[30 marks]

Solution:

Concept:

- A memory scene is convincing when the figures, equipment and utensils form one observable activity. Here the handpump, operating gesture and filling vessel must be the focal group.
- Overlap, scale changes and a common ground plane organise a group in depth. Sparse rural context and consistent shading support the subject without overwhelming it.

Step 1: Plan the group around the pump Place the handpump slightly off centre on a low paved platform, keeping its handle, upright body and outlet clearly visible. Arrange several village women around it in a loose triangular group. One operates the pump handle, another positions a pitcher beneath the outlet, and others wait with their utensils. Vary their positions rather than making a straight row: place one nearer the viewer and another partly behind the pump. Leave enough space between major silhouettes to distinguish arms, vessels and the machinery. A small path or courtyard edge can direct attention towards the group.

Step 2: Connect gestures to the water-filling action Construct the pump from a vertical body, a securely grounded base, a side spout and a long pivoted handle. Show the operating woman gripping the handle with a plausible bent arm and stance. Put the mouth of the filling pitcher below the spout, with a restrained water stream entering it. Show the woman tending that vessel bending or crouching naturally. Give the waiting women pitchers or metal utensils carried at the hip, supported in both hands or resting beside them. Use consistent ellipses for the vessel rims and enough curved contour to convey their rounded volume; avoid placing the stream beside the opening or merging a handle with an unrelated limb.

Step 3: Add rural context and finish the tones Suggest clothing with a few folds that follow each body and gesture, and maintain plausible proportions between adult figures, pump and containers. Indicate a village wall, a distant hut or a tree using light lines, leaving the central group dominant. Set a single lighting direction, add contact shadows beneath feet and utensils, and distinguish a small damp patch near the pump with subdued tone. Use the strongest contrast near the operating hand, spout and filling vessel; let distant details remain simpler. Finish the faces and garment edges only after the main action, ground contact and perspective are clear.

Step 4: Conclusion A suitable answer shows a group of village women gathered around a recognisable handpump, with one pumping and another filling a pitcher while others wait with utensils. Coherent gestures, vessel placement, rural context and consistent light make the scene legible and spatially

believable.

Quick Tip to Solve: Check the chain of action first: hand on handle, outlet over vessel opening, and vessel supported on the platform. These connections communicate water collection immediately.