JEE Main 2020 Paper 2A (B.Arch) Sep 1 Shift 2 Question Paper with Solutions PDF

Question Paper with Solutions

Conducted by the National Testing Agency (NTA)

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

General Instructions

(i) This paper is Paper 2A (B.Arch.) of JEE (Main) 2020, Session 2 (September), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 1 September 2020, Shift 2. The total duration is 3 hours.

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

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

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

(v) Marking scheme (numerical value questions): $+4$ for a correct answer, no negative marking and 0 for an unanswered question.

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

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

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

1. Let $A = \{1, 2, 3\}$. Define a relation R on A as :

$aRb \Leftrightarrow |a^2 - b^2| \leq 5$.

Then which of the following is not true ? [4 marks]

(A) $R^{-1} = R$, where R^{-1} is the inverse of R.

(B) Range of R is A.

(C) R is reflexive and symmetric.

(D) R is symmetric and transitive.

Correct Answer: (D) R is symmetric and transitive.

Solution:

Concept:

- A relation on A is a set of ordered pairs from $A \times A$. Reflexivity requires every pair (a, a), while symmetry requires (b, a) whenever (a, b) occurs.
- Transitivity requires (a, c) whenever both (a, b) and (b, c) occur. One counterexample suffices to disprove this universal condition.

Step 1: List the permitted ordered pairs The squares of the elements are $1, 4, 9$. The differences between distinct squares are $3, 5, 8$. Thus the pairs connecting 1 to 2 and 2 to 3 are permitted in both directions, but those connecting 1 to 3 are excluded. The complete relation is

$$R = \{(1, 1), (2, 2), (3, 3), (1, 2), (2, 1), (2, 3), (3, 2)\}.$$

Writing out this small relation makes it possible to check every assertion without overlooking a diagonal pair.

Step 2: Check the true assertions Every diagonal pair is present because $|a^2 - a^2| = 0 \leq 5$, so the relation is reflexive. Also $|a^2 - b^2| = |b^2 - a^2|$, so it is symmetric. Reversing all ordered pairs consequently leaves the same set: $R^{-1} = R$. Each element occurs as a second coordinate in its diagonal pair, so the range is exactly A. Options (A), (B) and (C) are therefore true.

Step 3: Test the remaining transitivity claim We have $(1, 2) \in R$ and $(2, 3) \in R$, since the corresponding differences are 3 and 5. However, $|1^2 - 3^2| = 8 > 5$, hence $(1, 3) \notin R$. This violates transitivity. Symmetry alone does not force a chain of related elements to close.

Step 4: Conclusion R is reflexive and symmetric but is not transitive. Hence, the correct option is (D).

Quick Tip to Solve: For a relation defined by a distance bound, test a chain through the middle element: two allowed short gaps can combine into a forbidden larger gap.

2. The locus of the point $z = x + iy\ (x, y \in \mathbf{R}, i = \sqrt{-1})$ satisfying $\arg\left(\frac{z-3}{z+3}\right) = \frac{\pi}{3}$, is : [4 marks]

(A) a circle with radius $= 2\sqrt{3}$

(B) a circle with centre at $(\sqrt{3}, 0)$

(C) a circle with centre at $(0, 2\sqrt{3})$ and radius 3

(D) an ellipse with length of its minor axis $= 3$

Correct Answer: (A) a circle with radius $= 2\sqrt{3}$

Solution:

Concept:

- For a nonzero complex number $u + iv$ with argument $\pi/3$, both u and v are positive and $v = \sqrt{3}\,u$. The ratio is undefined at $z = -3$ and has no argument at $z = 3$.
- To find a locus, rationalise the denominator and then complete squares in the real equation. The argument condition may select only an arc of the supporting circle.

Step 1: Rationalise the given ratio For $z = x + iy$, multiply numerator and denominator by $x + 3 - iy$:

$$\frac{z-3}{z+3} = \frac{x^2 + y^2 - 9 + 6iy}{(x+3)^2 + y^2}.$$

The denominator is strictly positive wherever the ratio is defined. Therefore its sign does not change the argument, and the real and imaginary numerators determine the required angle.

Step 2: Impose the argument and complete squares The angle $\pi/3$ gives

$$6y = \sqrt{3}(x^2 + y^2 - 9).$$

Rearranging and completing the square,

$$x^2 + y^2 - 2\sqrt{3}\,y = 9, \qquad x^2 + (y - \sqrt{3})^2 = 12.$$

Thus the supporting circle has centre $(0, \sqrt{3})$ and radius $\sqrt{12} = 2\sqrt{3}$. The original argument condition additionally requires positive real and imaginary parts; it selects the portion with $y > 0$, excluding the real endpoints.

Step 3: Compare the listed descriptions Option (A) gives the correct radius. Option (B) places the centre on the wrong axis. Option (C) gives both a different centre and a different radius. Option (D) describes an ellipse with a minor-axis length inconsistent with this circle. Strictly, the argument equation traces an arc, rather than the entire circle; among the options, (A) identifies the circle containing that locus.

Step 4: Conclusion The locus lies on $x^2 + (y - \sqrt{3})^2 = 12$, whose radius is $2\sqrt{3}$. Hence, the correct option is (A).

Quick Tip to Solve: After using a tangent equation for an argument, retain the quadrant restriction; otherwise an unwanted arc can be included.

3. If both the roots of the equation, $x^2 - 2ax + a^2 - 1 = 0 (a \in \mathbf{R})$ lie in the interval $(-2, 2)$, then the equation, $x^2 - \left(a^2 + 1\right) x - \left(a^2 + 2\right) = 0$ has [4 marks]

(A) both roots in $(-3, 0)$

(B) one root in $(0, 2)$ and another root in $(-2, 0)$

(C) one root in $[2, 3)$ and another root in $(-2, 0)$

(D) one root in $(-3, -2)$ and another root in $(0, 2]$

Correct Answer: (C) one root in $[2, 3)$ and another root in $(-2, 0)$

Solution:

Concept:

- Factoring a quadratic gives its exact roots and is more direct here than applying general interval tests. The first equation is $(x - a)^2 = 1$.
- An open interval excludes its endpoints. Bounds on a must therefore be kept strict before squaring to obtain bounds on a^2.

Step 1: Bound the parameter using the first equation The roots are $a - 1$ and $a + 1$. Both must lie strictly between -2 and 2. Since $a - 1 < a + 1$, the extreme conditions are

$$-2 < a - 1, \qquad a + 1 < 2.$$

These reduce to $-1 < a < 1$. The remaining two inequalities are then automatically satisfied. Consequently, $0 \leq a^2 < 1$, with the lower endpoint attained at $a = 0$.

Step 2: Factor the second equation exactly Put $t = a^2$, so $0 \leq t < 1$. The second polynomial factors as

$$x^2 - (t + 1)x - (t + 2) = (x + 1)(x - t - 2).$$

Indeed the sum of the roots is $-1 + (t + 2) = t + 1$, and their product is $-(t + 2)$, agreeing with the coefficients. Its roots are therefore -1 and $t + 2$.

Step 3: Locate both roots and eliminate the other choices The negative root -1 belongs to $(-2, 0)$. The other root satisfies $2 \leq t + 2 < 3$, so it lies in $[2, 3)$. Option (A) is impossible because one root is positive. Option (B) incorrectly excludes the value 2 and puts the positive root below 2. Option (D) gives a negative interval that does not contain -1. The inclusion of 2 in option (C) is necessary because $a = 0$ is allowed.

Step 4: Conclusion One root is $-1 \in (-2, 0)$, and the other is $a^2 + 2 \in [2, 3)$. Hence, the correct option is (C).

Quick Tip to Solve: Before using a discriminant or root-location theorem, try substituting a small integer: the second polynomial has the fixed root -1.

4. If the system of equations

$$2x + y + pz = -1$$

$$3x - 2y + z = q$$

$$5x - 8y + 9z = 5$$

has more than one solution, then $q - p$ is equal to : [4 marks]

(A) 2

(B) -2

(C) 4

(D) -4

Correct Answer: (C) 4

Solution:

Concept:

- A three-variable linear system has more than one solution only if its coefficient matrix is singular and the augmented equations are consistent. A dependent coefficient row must have the same dependence among its constants.
- Here the coefficients of x and y in the first two equations are independent: their determinant is $2(-2) - 3(1) = -7 \neq 0$. Thus any dependence of the third row on them is uniquely determined.

Step 1: Find the required row dependence Write the third coefficient row as α times the first plus β times the second. Comparing the first two columns gives

$$2\alpha + 3\beta = 5, \qquad \alpha - 2\beta = -8.$$

The second equation yields $\alpha = 2\beta - 8$. Substitution into the first gives $7\beta = 21$, hence $\beta = 3$ and $\alpha = -2$. Therefore singularity requires the third equation to equal minus twice the first plus three times the second.

Step 2: Enforce the same relation for the remaining column and constant The coefficient of z in that combination is $-2p + 3$. Equating it to 9 gives

$$-2p + 3 = 9 \quad \Rightarrow \quad p = -3.$$

The right-hand side of the same combination is $-2(-1) + 3q = 2 + 3q$. For consistency this must equal 5, so

$$2 + 3q = 5 \quad \Rightarrow \quad q = 1.$$

Without the second condition the system would be inconsistent, rather than have multiple solutions.

Step 3: Confirm multiplicity and evaluate the requested difference With these values, the third equation is exactly dependent on the first two. Those first two remain independent, so the system has

rank 2 in three unknowns, leaving one free parameter and hence infinitely many solutions. Finally, $q-p=1-(-3)=4$. The other proposed values 2, -2 and -4 do not satisfy this computed difference.

Step 4: Conclusion $p=-3$ and $q=1$, so $q-p=4$. Hence, the correct option is (C).

Quick Tip to Solve: For infinitely many solutions, match both the coefficients and the constants in a row dependence; a zero determinant alone is insufficient.

5. All the words (with or without meaning) formed using all the five letters of the word GOING are arranged as in dictionary. Then the word OGGIN occurs at the place which is : [4 marks]

(A) $(48)^{\text{th}}$

(B) $(49)^{\text{th}}$

(C) $(50)^{\text{th}}$

(D) $(51)^{\text{th}}$

Correct Answer: (B) $(49)^{\text{th}}$

Solution:

Concept:

- Dictionary order compares letters from left to right using $G<I<N<O$. The rank of a word is one plus the number of distinct words that precede it.
- If n letters include two identical Gs, their distinct arrangements number $n!/2!$. Identical copies must not be treated as separately labelled letters.

Step 1: Count words whose first letter is before O The multiset of letters is $\{G,G,I,N,O\}$. All words beginning with G, I or N precede OGGIN. If the first letter is G, the remaining G, I, N and O are distinct, giving $4!=24$ words. If it is I, the remaining letters are G, G, N and O, giving $4!/2!=12$ words. Similarly, a first letter N gives another $4!/2!=12$ words. Thus

$$24+12+12=48$$

words occur before the block beginning with O.

Step 2: Find the position within the O block After fixing O, the remaining multiset is $\{G,G,I,N\}$. Its earliest dictionary arrangement is GGIN: choose the smallest available letter at each position. This is precisely the suffix of OGGIN. Hence no word beginning with O comes before the target. In particular, one must not add an extra block for swapping the identical Gs; that would count the same word again.

Step 3: Convert the preceding count into rank There are exactly 48 distinct words preceding OGGIN, so its one-based position is

$$48+1=49.$$

The value 48 in option (A) counts preceding words rather than the target position. The values 50 and 51 in options (C) and (D) would require one or two earlier words in the O block, but GGIN is already the first suffix in that block. This establishes the rank without listing all $5!/2!=60$ arrangements.

Step 4: Conclusion OGGIN occupies the 49^{th} place. Hence, the correct option is (B).

Quick Tip to Solve: Count words before the target, then add one for its rank. Divide by the factorial of each repeated-letter multiplicity in every prefix block.

6. The sum

$-\frac{2}{3}+\frac{2}{9^2}+\frac{10}{9^3}+\frac{18}{9^4}+\frac{26}{9^5}+\ldots\ldots$ **upto infinity, is equal to :** [4 marks]

(A) $-\frac{5}{8}$

(B) $\frac{17}{24}$

(C) $-\frac{11}{24}$

(D) $\frac{5}{8}$

Correct Answer: (A) $-\frac{5}{8}$

Solution:

Concept:

- An arithmetic-geometric series has a numerator in arithmetic progression and a geometric denominator. Since $|r|<1$, $\sum_{n=1}^{\infty} r^n = r/(1-r)$ and $\sum_{n=1}^{\infty} nr^n = r/(1-r)^2$.
- Put every term over the same pattern of denominator before identifying its numerator. In particular, $-2/3 = -6/9$, which supplies the first numerator.

Step 1: Express the general term correctly Rewrite the displayed series as

$$S = \frac{-6}{9}+\frac{2}{9^2}+\frac{10}{9^3}+\frac{18}{9^4}+\cdots.$$

The numerators $-6, 2, 10, 18, 26, \ldots$ increase by 8. Their n-th term is $-6+8(n-1) = 8n-14$. Thus, with $r = 1/9$,

$$S = \sum_{n=1}^{\infty}(8n-14)r^n.$$

The series is absolutely convergent because a linear factor in n is dominated by the geometric decay.

Step 2: Apply the two standard infinite sums Split the convergent series into

$$S = 8\sum_{n=1}^{\infty} nr^n - 14\sum_{n=1}^{\infty} r^n.$$

At $r = 1/9$,

$$\frac{r}{1-r} = \frac{1}{8}, \qquad \frac{r}{(1-r)^2} = \frac{9}{64}.$$

Consequently,

$$S = 8\left(\frac{9}{64}\right) - 14\left(\frac{1}{8}\right) = \frac{9}{8} - \frac{7}{4} = -\frac{5}{8}.$$

Keeping the original first term negative is essential; the positive tail does not outweigh it.

Step 3: Check the sign and the listed alternatives The first term is about -0.6667, and the next two terms are about 0.02469 and 0.01372, so a sum near -0.625 is reasonable. This rules out the positive values in options (B) and (D). Option (C), $-11/24$, is too large and disagrees with the exact summed formula. Option (A) agrees with both the calculation and the sign check.

Step 4: Conclusion The infinite sum is $-\frac{5}{8}$. Hence, the correct option is (A).

Quick Tip to Solve: Rewrite an exceptional-looking first term over the first geometric denominator; here $-2/3 = -6/9$ reveals the numerator progression immediately.

7. Let r and s be respectively the remainders when $(12)^{23}$ and $(23)^{12}$ are divided by 5, then $r+s$ is equal to : [4 marks]

(A) 5

(B) 4

(C) 3

(D) 2

Correct Answer: (B) 4

Solution:

Concept:

- Replacing an integer by its remainder modulo 5 does not change the remainder of any positive integral power of that integer.
- The nonzero powers modulo 5 repeat with period 4: $u^4 \equiv 1 \pmod 5$ when u is not divisible by 5. A remainder must be one of 0, 1, 2, 3 or 4.

Step 1: Reduce the bases and the first exponent Since $12 \equiv 2 \pmod 5$, work with powers of 2 instead of expanding the large integer. The cycle is $2, 4, 3, 1$, because $2^4 = 16 \equiv 1 \pmod 5$. Write $23 = 4 \cdot 5 + 3$. Hence

$$12^{23} \equiv 2^{23} = (2^4)^5\, 2^3 \equiv 1^5 \cdot 8 \equiv 3 \pmod 5.$$

Thus the first division leaves remainder $r = 3$, rather than the unreduced value 8.

Step 2: Find the second remainder and add For the second integer, $23 \equiv 3 \pmod 5$. Since $3^4 = 81 \equiv 1 \pmod 5$, and 12 is a multiple of the cycle length, we obtain

$$23^{12} \equiv 3^{12} = (3^4)^3 \equiv 1 \pmod 5.$$

Therefore $s = 1$, and $r + s = 3 + 1 = 4$. Option (A), 5, is too large for this actual sum; option (C), 3, retains only the first remainder; option (D), 2, does not agree with either the cycle computation or the sum. Do not reduce the requested sum again modulo 5: the question asks for the ordinary sum of the two remainders.

Step 3: Conclusion The remainders are $r = 3$ and $s = 1$, so $r + s = 4$. Hence, the correct option is (B).

Quick Tip to Solve: First reduce each base modulo 5, then reduce its exponent modulo 4; only after finding both individual remainders should you add them.

8. Let f be a differentiable function satisfying $f(x+y) = f(x) + f(y) - xy$ for all $x, y \in \mathbf{R}$. If $\lim_{h\to 0} \frac{f(h)}{h} = 3$, then $\sum_{n=1}^{10} f(n)$ is equal to : [4 marks]

(A) $-\frac{55}{2}$

(B) $\frac{275}{2}$

(C) $-\frac{55}{4}$

(D) $\frac{225}{4}$

Correct Answer: (A) $-\frac{55}{2}$

Solution:

Concept:

- The derivative is obtained from the difference quotient $f'(x) = \lim_{h\to 0}[f(x+h) - f(x)]/h$. The given functional equation supplies this difference directly.
- Once the derivative is known, integrate it and use $f(0)$ to determine the constant. For the final sum use $\sum_{n=1}^{10} n = 55$ and $\sum_{n=1}^{10} n^2 = 385$.

Step 1: Determine the value at zero and the derivative Putting $x = y = 0$ in the functional equation gives $f(0) = 2f(0)$, so $f(0) = 0$. Next, take $y = h$ and subtract $f(x)$:

$$\frac{f(x+h) - f(x)}{h} = \frac{f(h)}{h} - x.$$

The supplied limit is 3, so passing to the limit gives $f'(x) = 3 - x$ for every real x. This step uses the actual minus sign in the term $-xy$; reversing that sign would change the entire quadratic.

Step 2: Recover the function and evaluate the finite sum Integrating gives $f(x) = 3x - x^2/2 + C$. The already established condition $f(0) = 0$ makes $C = 0$. Consequently

$$\begin{aligned}\sum_{n=1}^{10} f(n) &= 3\sum_{n=1}^{10} n - \frac{1}{2}\sum_{n=1}^{10} n^2 \\ &= 3(55) - \frac{385}{2} = -\frac{55}{2}.\end{aligned}$$

As a check, substituting the quadratic into $f(x+y)$ produces the cross term $-xy$, as required. Option (B) is positive and cannot equal this sum. Options (C) and (D) have denominator 4 and do not follow from the coefficient $-1/2$ of x^2; neither matches the exact arithmetic above.

Step 3: Conclusion We obtain $f(x) = 3x - \frac{x^2}{2}$, and $\sum_{n=1}^{10} f(n) = -\frac{55}{2}$. Hence, the correct option is (A).

Quick Tip to Solve: In a differentiable functional equation, set one variable equal to a small increment and divide by that increment before taking its limit.

9. For non-zero real numbers a, b, if $y(x) = \frac{a+bx^{3/2}}{x^{5/4}}, x > 0$ and $y''(5) = 0$, then the ratio $a : b$ is :

[4 marks]

(A) $\sqrt{5} : 3$

(B) $3 : \sqrt{5}$

(C) $\sqrt{5} : \sqrt{3}$

(D) $3 : 1$

Correct Answer: (A) $\sqrt{5} : 3$

Solution:

Concept:

- For $x > 0$, fractional powers can be differentiated using $\frac{d}{dx}x^p = px^{p-1}$. Rewrite a quotient of powers as a sum before differentiating.
- The condition $y''(5) = 0$ is a linear relation between the nonzero constants a and b; divide by a nonzero common factor to obtain their ratio.

Step 1: Rewrite the expression and differentiate twice Distribute the denominator over the two terms in the numerator. Since $3/2 - 5/4 = 1/4$, the function becomes

$$y = ax^{-5/4} + bx^{1/4}.$$

Applying the power rule separately gives

$$y' = -\frac{5a}{4}x^{-9/4} + \frac{b}{4}x^{-3/4},$$
$$y'' = \frac{45a}{16}x^{-13/4} - \frac{3b}{16}x^{-7/4}.$$

In particular, the second term in the second derivative is negative, even though its term in the original function is positive.

Step 2: Use the value at five and compare the ratios At $x = 5$, multiply the zero second derivative by the positive quantity $16 \cdot 5^{13/4}$. This removes both negative powers without changing the equation:

$$45a - 3b\,5^{3/2} = 0.$$

Hence $15a = 5\sqrt{5}\,b$, and division by $15b$, valid because $b \neq 0$, yields

$$\frac{a}{b} = \frac{\sqrt{5}}{3}.$$

Option (B) reverses the desired ratio. Option (C) gives $a/b = \sqrt{5/3}$, and option (D) gives $a/b = 3$; neither satisfies $15a = 5\sqrt{5}\,b$. The result also shows that a and b have the same sign, consistent with cancellation in the second derivative.

Step 3: Conclusion The ratio is $a : b = \sqrt{5} : 3$. Hence, the correct option is (A).

Quick Tip to Solve: Split the quotient into powers first. In the zero second derivative, multiply by the largest denominator power so only the exponent difference remains.

10. The function $f(x) = \sin 2x + 2\cos x, x \in \left(-\frac{3\pi}{4}, \frac{3\pi}{4}\right)$ has : [4 marks]

(A) no critical point.

(B) a point of local maxima and a point of local minima.

(C) a point of local maxima and a point of inflection.

(D) a point of local minima and a point of inflection.

Correct Answer: (C) a point of local maxima and a point of inflection.

Solution:

Concept:

- An interior critical point of a differentiable function satisfies $f'(x) = 0$. A local maximum requires the derivative to change from positive to negative.
- A point of inflection requires a change in concavity. A zero second derivative alone is insufficient; check its sign on the two sides, especially at a repeated root of the first derivative.

Step 1: Factor the derivative and classify the stationary points Differentiate and use $\cos 2x = 1 - 2\sin^2 x$:

$$f'(x) = 2(\cos 2x - \sin x) = -2(2\sin x - 1)(\sin x + 1).$$

Within the stated open interval, its zeros are $x = \pi/6$ and $x = -\pi/2$. The other solution $5\pi/6$ of $\sin x = 1/2$ is outside the interval. Apart from $-\pi/2$, the factor $\sin x + 1$ is positive. Thus f' is positive before $\pi/6$ and negative afterwards. There is a local maximum at $\pi/6$. Near $-\pi/2$, $\sin x < 1/2$, so the derivative is positive on both sides: this critical point is not a local minimum.

Step 2: Verify the stationary inflection point The second derivative is

$$f''(x) = -4\sin 2x - 2\cos x = -2\cos x(4\sin x + 1).$$

Near $-\pi/2$, the factor $4\sin x + 1$ is negative. The cosine is negative immediately to the left and positive immediately to the right. Therefore f'' changes from negative to positive there: $-\pi/2$ is a stationary point of inflection. Option (A) is false because critical points exist. Option (B) is false because neither stationary point is a local minimum; (D) likewise requires a local minimum that does not occur. Option (C) correctly states the presence of a local maximum and an inflection point.

Step 3: Conclusion The function has a local maximum at $x = \pi/6$ and a stationary point of inflection at $x = -\pi/2$. Hence, the correct option is (C).

Quick Tip to Solve: A repeated factor in the first derivative can give a stationary inflection instead of an extremum. Check derivative signs before calling it a minimum.

11. The integral $\int \frac{\cos^5\theta}{\sin\theta(4-3\sin^2 2\theta)}d\theta$ is equal to :

(where C is a constant of integration) [4 marks]

(A) $\frac{1}{5}\log_e\left|\frac{\cos^5\theta}{\sin^5\theta+\cos^5\theta}\right|+C$

(B) $\frac{1}{24}\log_e\left(\frac{\sin^6\theta}{\sin^6\theta+\cos^6\theta}\right)+C$

(C) $\frac{1}{20}\log_e\left|\frac{\sin^5\theta}{\sin^5\theta+\cos^5\theta}\right|+C$

(D) $\frac{1}{6}\log_e\left(\frac{\cos^6\theta}{\sin^6\theta+\cos^6\theta}\right)+C$

Correct Answer: (B) $\frac{1}{24}\log_e\left(\frac{\sin^6\theta}{\sin^6\theta+\cos^6\theta}\right)+C$

Solution:

Concept:

- The identity $u^3+v^3=(u+v)^3-3uv(u+v)$, with $u=\sin^2\theta$, $v=\cos^2\theta$, gives $\sin^6\theta+\cos^6\theta=1-3\sin^2\theta\cos^2\theta$.
- The substitution $t=\tan\theta$ converts ratios of sine and cosine to rational powers. Integrate $1/[t(1+t^6)]$ by separating a logarithmic derivative.

Step 1: Simplify the trigonometric denominator Because $\sin^2 2\theta=4\sin^2\theta\cos^2\theta$, write

$$4-3\sin^2 2\theta=4(\sin^6\theta+\cos^6\theta).$$

On an interval where $\cos\theta\neq 0$, put $t=\tan\theta$, so $d\theta=\cos^2\theta\,dt$. Dividing by the appropriate cosine powers then gives

$$I=\frac{1}{4}\int\frac{dt}{t(1+t^6)}.$$

This is a rational integral; no expansion into a long trigonometric polynomial is needed.

Step 2: Integrate and return to the original variable Use $1/[t(1+t^6)]=1/t-t^5/(1+t^6)$. Therefore

$$\begin{aligned}I&=\frac{1}{4}\ln|t|-\frac{1}{24}\ln(1+t^6)+C\\&=\frac{1}{24}\ln\left(\frac{t^6}{1+t^6}\right)+C\\&=\frac{1}{24}\ln\left(\frac{\sin^6\theta}{\sin^6\theta+\cos^6\theta}\right)+C.\end{aligned}$$

The logarithm's argument is positive wherever $\sin\theta\neq 0$, which is already required by the original denominator. The final expression also extends across points with $\cos\theta=0$, where the original integrand is regular. Differentiating the logarithmic expression reverses the rational substitution and recovers the original integrand. Options (A) and (C) involve fifth powers and do not produce the denominator $1+t^6$. Option (D) differentiates to a multiple of $-t^5/(1+t^6)$, rather than $1/[4t(1+t^6)]$.

Step 3: Conclusion The integral is $\frac{1}{24}\log_e\left(\frac{\sin^6\theta}{\sin^6\theta+\cos^6\theta}\right)+C$. Hence, the correct option is (B).

Quick Tip to Solve: When $4-3\sin^2 2\theta$ appears, rewrite it as $4(\sin^6\theta+\cos^6\theta)$; the tangent substitution then becomes rational.

12. The area (in sq. units) of the region bounded by the parabola $x = 2y^2$ and the line $x + y = 1$ is : [4 marks]

(A) $\frac{11}{12}$
(B) $\frac{13}{24}$
(C) $\frac{9}{8}$
(D) $\frac{5}{4}$

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

Solution:

Concept:

- For curves written as $x = x(y)$, the enclosed area is $\int (x_{\text{right}} - x_{\text{left}})\, dy$ between their intersection ordinates.
- Find all intersections first, then test which curve is to the right inside that interval. Integrating with respect to y avoids splitting this sideways parabola into two square-root branches.

Step 1: Find the intersection ordinates and the horizontal width The line is $x = 1 - y$, whereas the parabola is $x = 2y^2$. At an intersection their abscissae are equal:

$$2y^2 = 1 - y, \qquad 2y^2 + y - 1 = (2y - 1)(y + 1) = 0.$$

Thus the two limits are $y = -1$ and $y = 1/2$. Between them, the difference $1 - y - 2y^2$ is nonnegative; for instance, at $y = 0$ the line gives $x = 1$ and the parabola gives $x = 0$. Therefore the line is the right boundary and the parabola the left boundary throughout the enclosed region.

Step 2: Integrate the width and simplify the exact area The area is consequently

$$\begin{aligned} A &= \int_{-1}^{1/2} (1 - y - 2y^2)\, dy \\ &= \left[y - \frac{y^2}{2} - \frac{2y^3}{3} \right]_{-1}^{1/2} \\ &= \left(\frac{1}{2} - \frac{1}{8} - \frac{1}{12} \right) - \left(-1 - \frac{1}{2} + \frac{2}{3} \right) \\ &= \frac{7}{24} + \frac{5}{6} = \frac{27}{24} = \frac{9}{8}. \end{aligned}$$

The positive result is consistent with integrating a nonnegative width. Option (A), $11/12$, and option (B), $13/24$, are smaller than the exact difference of endpoint values; option (D), $5/4$, is larger. None equals $27/24$. Retaining the negative sign of the lower-endpoint value is essential: the lower value is $-5/6$, so subtracting it adds $5/6$.

Step 3: Conclusion The enclosed area is $\frac{9}{8}$ square units. Hence, the correct option is (C).

Quick Tip to Solve: For a sideways parabola and a line, integrate horizontal widths in y. This uses one integral and avoids separating upper and lower square-root branches.

13. Let $y = y(x)$ be the solution of the differential equation $x \log_e x \frac{dy}{dx} + 2y = 2x (x > 1)$. If $\lim_{x \to 1+} y(x) = 1$, then $y\left(e^2\right)$ is equal to : [4 marks]

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

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

(C) $e^2 - 1$

(D) $e^2 + 1$

Correct Answer: (B) $\frac{e^2+1}{2}$

Solution:

Concept:

- A first-order linear differential equation $y' + P(x)y = Q(x)$ is solved using the integrating factor $\exp(\int P(x)\,dx)$.
- Here $x > 1$, so $\log x > 0$. The boundary condition is a one-sided limit at the point where the original equation is singular.

Step 1: Put the equation in linear form Divide by $x \log x$, which is nonzero on the specified domain. This gives

$$y' + \frac{2}{x \log x} y = \frac{2}{\log x}.$$

The integrating factor is

$$\exp\left(\int \frac{2}{x \log x}\,dx\right) = (\log x)^2.$$

Multiplying the entire equation by this factor combines the two terms on the left into one product derivative.

Step 2: Integrate and determine the constant The transformed equation and its integral are

$$\frac{d}{dx}\{y(\log x)^2\} = 2 \log x,$$

$$y(\log x)^2 = 2(x \log x - x) + C.$$

Since $y \to 1$ as $x \to 1+$, the left side tends to zero, whereas the right side tends to $-2 + C$. Consequently $C = 2$, and

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

This expression also has the required limit: applying l'Hopital twice gives $\lim_{x \to 1+} y(x) = 1$.

Step 3: Evaluate at the requested argument At $x = e^2$, the logarithm is 2, so

$$y(e^2) = \frac{2(2e^2 - e^2 + 1)}{4} = \frac{e^2 + 1}{2}.$$

Option (A) has the incorrect sign on the constant term. Options (C) and (D) omit the factor of two in the denominator, so none of those expressions equals the computed value.

Step 4: Conclusion $\boxed{y(e^2) = \frac{e^2 + 1}{2}}$. Hence, the correct option is (B).

Quick Tip to Solve: At a singular endpoint, first use finiteness to determine the integration constant; then verify the actual limiting value.

14. If $(x_i, y_i), i = 1, 2, 3$ are the vertices of an equilateral triangle such that

$$(x_1 + 3)^2 + (y_1 - 4)^2 = (x_2 + 3)^2 + (y_2 - 4)^2$$
$$= (x_3 + 3)^2 + (y_3 - 4)^2,$$

then the value of $\frac{y_1+y_2+y_3}{x_1+x_2+x_3}$ is : [4 marks]

(A) $\frac{4}{3}$

(B) $-\frac{4}{3}$

(C) $\frac{3}{4}$

(D) $-\frac{3}{4}$

Correct Answer: (B) $-\frac{4}{3}$

Solution:

Concept:

- Points equidistant from the three vertices of a nondegenerate triangle identify its circumcentre, the common intersection of the perpendicular bisectors.
- For an equilateral triangle, the circumcentre and centroid coincide. The centroid is $\big((x_1 + x_2 + x_3)/3, (y_1 + y_2 + y_3)/3\big)$.

Step 1: Interpret the three equal expressions Each expression in the question is a squared Euclidean distance. In particular,

$$(x_i + 3)^2 + (y_i - 4)^2 = (x_i - (-3))^2 + (y_i - 4)^2.$$

Thus the point $O = (-3, 4)$ is equidistant from all three vertices. The three vertices of an equilateral triangle are not collinear, so their circumcentre is unique. It follows that O is precisely that circumcentre; its first coordinate is negative because the expression contains $x_i + 3$.

Step 2: Use the coincidence of the centres In an equilateral triangle every median is also an altitude and a perpendicular bisector. Hence their common intersection is both the centroid and the circumcentre. Comparing centroid coordinates with $(-3, 4)$, we obtain

$$\frac{x_1 + x_2 + x_3}{3} = -3, \qquad \frac{y_1 + y_2 + y_3}{3} = 4.$$

Therefore the sums required in the question are -9 and 12, respectively. No individual vertex coordinates or side length need to be calculated.

Step 3: Form and check the ratio The denominator is $-9 \neq 0$, so the requested ratio is defined and equals

$$\frac{y_1 + y_2 + y_3}{x_1 + x_2 + x_3} = \frac{12}{-9} = -\frac{4}{3}.$$

The positive value in (A) loses the sign of the first coordinate. Options (C) and (D) interchange the numerator and denominator magnitudes, giving $3/4$ instead of $4/3$.

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

Quick Tip to Solve: Read equal sums of squared coordinate differences as equal distances from a fixed point; for an equilateral triangle that point is also the centroid.

15. If tangent at $\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ to the circle $x^2 + y^2 = 1$ is also a tangent to the circle $(x-a)^2 + (y-b)^2 = 1$, then the ordered pair (a, b) can be : [4 marks]

(A) $(-2, \sqrt{2})$

(B) $(-\sqrt{2}, 2\sqrt{2})$

(C) $(2, -2\sqrt{2})$

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

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

Solution:

Concept:

- The tangent to $x^2 + y^2 = r^2$ at a point (x_0, y_0) on the circle is $xx_0 + yy_0 = r^2$.
- A line $Ax + By + C = 0$ is tangent to a circle of centre (a, b) and radius r exactly when $|Aa + Bb + C|/\sqrt{A^2 + B^2} = r$.

Step 1: Find the specified tangent line The given point lies on the unit circle since $(1/\sqrt{2})^2 + (1/\sqrt{2})^2 = 1$. Substitution in the tangent formula gives

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

This is the one line whose tangency to the second circle must be tested. Its normal vector is $(1, 1)$, with magnitude $\sqrt{2}$.

Step 2: Apply the distance condition to the second circle The second circle also has radius one and centre (a, b). Consequently its distance from this line must equal one:

$$\frac{|a + b - \sqrt{2}|}{\sqrt{2}} = 1.$$

Equivalently, $a + b - \sqrt{2} = \pm\sqrt{2}$, which gives the two possible centre conditions

$$a + b = 0 \quad \text{or} \quad a + b = 2\sqrt{2}.$$

Both sides of a tangent line are possible locations for a centre, so retaining both signs is essential.

Step 3: Test the four proposed centres For (A), $a + b = -2 + \sqrt{2}$, which satisfies neither condition. For (B), $a + b = -\sqrt{2} + 2\sqrt{2} = \sqrt{2}$, so its centre actually lies on the line and the line is not tangent. For (C), $a + b = 2 - 2\sqrt{2}$, which also fails. For (D), $a + b = -\sqrt{2} + \sqrt{2} = 0$, so its perpendicular distance is exactly one. Thus only (D) meets the geometric requirement.

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

Quick Tip to Solve: For a candidate circle centre, test distance to the tangent line instead of solving the simultaneous equations of the line and circle.

16. The foci of a hyperbola coincide with the foci of the ellipse, $\frac{x^2}{16}+\frac{y^2}{9}=1$. If the eccentricity of the hyperbola is 4, then its equation is : [4 marks]

(A) $\frac{x^2}{7}-\frac{4y^2}{105}=\frac{1}{4}$

(B) $\frac{x^2}{7}-\frac{y^2}{105}=\frac{1}{16}$

(C) $\frac{x^2}{20}-\frac{y^2}{75}=\frac{1}{16}$

(D) $\frac{x^2}{5}-\frac{y^2}{75}=\frac{1}{16}$

Correct Answer: (B) $\frac{x^2}{7}-\frac{y^2}{105}=\frac{1}{16}$

Solution:

Concept:

- For an ellipse $x^2/A^2+y^2/B^2=1$, with $A>B$, its focal distance satisfies $c^2=A^2-B^2$.
- A horizontal hyperbola has focal relation $c^2=a^2+b^2$ and eccentricity $e=c/a$. Here a and b are its semi-axis parameters.

Step 1: Locate the common foci The ellipse has its major axis along the x-axis because $16>9$. Its focal distance is

$$c^2=16-9=7, \qquad c=\sqrt{7}.$$

Its foci, and hence those of the hyperbola, are $(\pm\sqrt{7},0)$. Therefore the hyperbola is centred at the origin and opens along the x-axis, giving the standard form $x^2/a^2-y^2/b^2=1$.

Step 2: Calculate the hyperbola parameters Use the given eccentricity of four with the common focal distance:

$$4=\frac{\sqrt{7}}{a} \quad \Longrightarrow \quad a^2=\frac{7}{16}.$$

The hyperbola focal identity uses addition rather than the ellipse subtraction. It gives

$$b^2=c^2-a^2=7-\frac{7}{16}=\frac{105}{16}.$$

Both parameters are positive, as required for a real horizontal hyperbola.

Step 3: Rewrite the equation in the offered form Substitute these squared parameters:

$$\frac{x^2}{7/16}-\frac{y^2}{105/16}=1.$$

Dividing both sides by sixteen produces

$$\frac{x^2}{7}-\frac{y^2}{105}=\frac{1}{16}.$$

This is (B). Option (A), after normalization, gives focal square $7/4+105/16=133/16$, not seven. Options (C) and (D) give focal squares $95/16$ and $80/16$, respectively, so they cannot share the stated foci.

Step 4: Conclusion $\boxed{\frac{x^2}{7}-\frac{y^2}{105}=\frac{1}{16}}$. Hence, the correct option is (B).

Quick Tip to Solve: Confocal conics share c, not their semi-axis lengths. Use $e=c/a$ first and then the correct focal identity for each conic.

17. If the plane $\mathrm{P}: 2x - y + 3z + 5 = 0$ is rotated through 90° about its line of intersection with the plane $5x - 4y - 2z + 1 = 0$, then the equation of the plane P in the new position is : [4 marks]

(A) $27x - 24y - 26z + 13 = 0$

(B) $27x - 24y - 26z - 13 = 0$

(C) $31x + 2y - 20z - 13 = 0$

(D) $31x - 25y + 29z + 13 = 0$

Correct Answer: (B) $27x - 24y - 26z - 13 = 0$

Solution:

Concept:

- Every plane through the intersection of two nonparallel planes $P = 0$ and $Q = 0$ can be written as $P + \lambda Q = 0$, together with the limiting member $Q = 0$.
- Planes are perpendicular when their normal vectors have zero dot product. Rotating a plane by 90° about a line in it produces a perpendicular plane containing that line.

Step 1: Write the plane through the fixed rotation axis The common line remains fixed throughout the rotation. Thus the new plane has equation

$$(2x - y + 3z + 5) + \lambda(5x - 4y - 2z + 1) = 0.$$

Its normal is $(2 + 5\lambda, -1 - 4\lambda, 3 - 2\lambda)$. The original normal is $(2, -1, 3)$. The second plane alone is not the desired limiting member because its normal has dot product 8, rather than zero, with the original normal.

Step 2: Impose the right-angle rotation The original and final planes must be perpendicular, so

$$2(2 + 5\lambda) - (-1 - 4\lambda) + 3(3 - 2\lambda) = 0.$$

Collecting constant and parameter terms yields

$$14 + 8\lambda = 0, \qquad \lambda = -\frac{7}{4}.$$

Multiplying the family equation by four avoids fractional coefficients and gives $4P - 7Q = 0$.

Step 3: Expand and verify the selected plane Expansion gives

$$-27x + 24y + 26z + 13 = 0.$$

Multiplication by -1 puts it in the offered form:

$$27x - 24y - 26z - 13 = 0.$$

Its normal has dot product $54 + 24 - 78 = 0$ with $(2, -1, 3)$, and being a linear combination of the original equations it contains their entire intersection. Option (A) changes only the constant and therefore misses the fixed line. The normals of (C) and (D) have dot products, 0 and 174, respectively; (C), though perpendicular, also fails to contain the axis.

Step 4: Conclusion $\boxed{27x - 24y - 26z - 13 = 0}$. Hence, the correct option is (B).

Quick Tip to Solve: A rotated plane about a fixed intersection line must satisfy two tests: belong to the plane pencil and have the required normal angle.

18. The top of two poles, standing 4 m apart on a horizontal plane, are connected by a cable. If the angles of depression from the top of one pole to the bottom of another pole are 30° and 45°, then the minimum length (in m) of the cable is : [4 marks]

(A) $\sqrt{\frac{32\sqrt{3}-16}{3}}$

(B) $\sqrt{\frac{128-32\sqrt{3}}{3}}$

(C) $\sqrt{\frac{122-32\sqrt{3}}{3}}$

(D) $\sqrt{\frac{112-32\sqrt{3}}{3}}$

Correct Answer: (D) $\sqrt{\frac{112-32\sqrt{3}}{3}}$

Solution:

Concept:

- For a vertical pole and a horizontal separation d, an angle of depression θ from its top to the other base gives height $h = d\tan\theta$.
- The shortest cable joining two fixed tops is the straight segment. Its length follows from the horizontal separation and the difference of their heights.

Step 1: Calculate the two pole heights The angles of depression are measured from the horizontal at the tops to the opposite bases. Since the pole bases are on the same horizontal plane and four metres apart, the right triangles give

$$h_1 = 4\tan 30^\circ = \frac{4}{\sqrt{3}}\ \text{m},$$

$$h_2 = 4\tan 45^\circ = 4\ \text{m}.$$

The pole associated with the larger angle is taller, as expected. Interchanging their names does not affect the length between their tops.

Step 2: Find the shortest top-to-top distance The horizontal component of the displacement between tops remains 4 m, and the vertical component is

$$h_2 - h_1 = 4 - \frac{4}{\sqrt{3}}.$$

A sagging cable would be longer than the straight segment, so the minimum possible length L is the Euclidean distance

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

Using the sum of the heights here would instead describe points on opposite sides of the base plane,

which is not the stated configuration.

Step 3: Simplify and compare the choices Expanding carefully,

$$L^2 = 16 + 16 + \frac{16}{3} - \frac{32}{\sqrt{3}} = \frac{112 - 32\sqrt{3}}{3}.$$

Taking the positive square root gives the physical cable length. Option (D) has exactly this squared value. The constants in (B) and (C) are too large, while (A) gives a squared length smaller than 16, impossible because any segment joining the tops must be at least the four-metre horizontal separation.

Step 4: Conclusion $\boxed{L = \sqrt{\frac{112 - 32\sqrt{3}}{3}}\ \text{m}}$. Hence, the correct option is (D).

Quick Tip to Solve: For a cable joining two tops, apply Pythagoras with the difference of pole heights; check that the result exceeds the horizontal separation.

19. Let A, B and C be three events such that the probability of occurrence of exactly one of A and B is $\frac{1}{2}$, the probability of occurrence of exactly one of B and C is $\frac{3}{4}$ and the probability of occurrence of exactly one of C and A is $\frac{1}{4}$. If the probability of occurrence of all the three events simultaneously is $\frac{1}{16}$, then the probability that at least one of the three events will occur is : [4 marks]

(A) $\frac{7}{16}$
(B) $\frac{13}{16}$
(C) $\frac{7}{8}$
(D) $\frac{15}{16}$

Correct Answer: (B) $\frac{13}{16}$

Solution:

Concept:

- The event that exactly one of two events occurs is their symmetric difference: $P(A \triangle B) = P(A) + P(B) - 2P(A \cap B)$.
- For three events, inclusion-exclusion gives $P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(C \cap A) + P(A \cap B \cap C)$.

Step 1: Add the three pairwise probabilities Write $S = P(A) + P(B) + P(C)$ and $T = P(A \cap B) + P(B \cap C) + P(C \cap A)$. Adding the three given probabilities counts each single-event probability twice and subtracts each pair-intersection probability twice. Thus

$$2S - 2T = \frac{1}{2} + \frac{3}{4} + \frac{1}{4} = \frac{3}{2}.$$

Dividing by two gives $S - T = \frac{3}{4}$. This relation already combines every probability needed except the triple intersection.

Step 2: Apply inclusion-exclusion The requested probability is a union, so the outcomes in which all

three events occur must be included once. Substitute the supplied triple-intersection probability:

$$P(A \cup B \cup C) = S - T + \frac{1}{16} = \frac{3}{4} + \frac{1}{16} = \frac{13}{16}.$$

The other candidates $7/16$, $7/8$, and $15/16$ do not equal this inclusion-exclusion result. In particular, the sum of the three symmetric differences is not itself the union probability; treating it as such counts outcomes incorrectly.

Step 3: Conclusion The probability that at least one event occurs is $\boxed{13/16}$. Hence, the correct option is (B).

Quick Tip to Solve: Add the three symmetric-difference probabilities and halve the result; then add the probability of the triple intersection to obtain the union.

20. Let

p **: I have passed JEE (Main),**

q **: My JEE (Main) rank is 100, and**

r **: I will appear in JEE (Advanced)**

be three statements with truth values T, F and T respectively. Then which one of the following has the truth value, F ? [4 marks]

(A) $(\sim p \vee \sim q) \wedge r$

(B) $(p \wedge \sim q) \vee (\sim r)$

(C) $(\sim p \vee q) \wedge (\sim r)$

(D) $(\sim p \wedge q) \vee r$

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

Solution:

Concept:

- Negation reverses a truth value. Here $p = T$, $q = F$, $r = T$, so $\sim p = F$, $\sim q = T$, and $\sim r = F$.
- A conjunction $u \wedge v$ is true only when both inputs are true; a disjunction $u \vee v$ is false only when both inputs are false.

Step 1: Substitute the truth values Evaluate the expressions inside parentheses before combining them. The statement about passing JEE (Main) is true, the statement about rank 100 is false, and the statement about appearing in JEE (Advanced) is true. Their real-world relationship does not impose any extra condition: the question directly supplies their truth values. In option (A), the first disjunction is $F \vee T = T$, while in option (B), the first conjunction is $T \wedge T = T$.

Step 2: Evaluate all four alternatives Using the logical operations gives

$$(A) : (F \vee T) \wedge T = T,$$
$$\text{(B)} : (T \wedge T) \vee F = T,$$
$$\text{(C)} : (F \vee F) \wedge F = F,$$
$$\text{(D)} : (F \wedge F) \vee T = T.$$

Option (C) is false because both its first disjunction and its negated-r statement are false. Option (D) is true even though its first conjunction is false: its disjunction with the true statement r makes the complete expression true. The first two options are true by the explicit calculations above.

Step 3: Conclusion Only $(\sim p \vee q) \wedge (\sim r)$ has truth value F. Hence, the correct option is (C).

Quick Tip to Solve: Write the three negated truth values first, then evaluate each parenthesis. A final disjunction with a true statement is always true.

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

21. Let $B = \begin{bmatrix} 22 & -26 \\ -6 & 10 \end{bmatrix}$ be the matrix obtained by applying the elementary row operations $R_2 \to R_2 - R_1$, $R_1 \to 2R_1$ and $R_1 \to R_1 - 2R_2$ (in this order only) on a matrix A. Then the sum of all entries of A is _____. [4 marks]

Solution:

Concept:

- An elementary row operation is reversed by applying its inverse; to recover the original matrix, undo the operations in reverse order.
- The inverse of doubling a row is halving that row. The inverse of adding a multiple of another row is subtracting the same multiple, using the row values at that stage.

Step 1: Undo the last row replacement The final rows of B are $(22, -26)$ and $(-6, 10)$. The last operation was $R_1 \to R_1 - 2R_2$; its inverse is $R_1 \to R_1 + 2R_2$. Hence the row before that last replacement was

$$R_1 = (22, -26) + 2(-6, 10) = (10, -6).$$

The second row is unchanged by this inverse and remains $(-6, 10)$. At this point the original first row is still doubled; we have not yet recovered A.

Step 2: Undo the doubling and the first replacement Undo $R_1 \to 2R_1$ by dividing the current first row by two:

$$R_1 = (5, -3).$$

Now undo the initial operation $R_2 \to R_2 - R_1$ by adding this recovered first row:

$$R_2 = (-6, 10) + (5, -3) = (-1, 7).$$

Therefore

$$A = \begin{pmatrix} 5 & -3 \\ -1 & 7 \end{pmatrix}, \qquad \sum a_{ij} = 5 - 3 - 1 + 7 = 8.$$

As a forward check, subtracting the first row gives $(-6, 10)$, doubling the first gives $(10, -6)$, and subtracting twice the second gives $(22, -26)$, exactly reproducing B.

Step 3: Conclusion The sum of all entries of A is $\boxed{8}$. This is a dimensionless numerical value.

Quick Tip to Solve: Reverse the order as well as the sign of row operations. Halve the first row before using it to undo the original second-row subtraction.

22. For $b \in \mathbf{N}$, if the limit of the function

$$f(x) = \begin{cases} [5x - 4], & x < 4, \\ \dfrac{[x + b]}{2}, & x > 4 \end{cases}$$

when $x \to 4$, exists and $[t]$ denotes the greatest integer $\leq t$, then b is equal to _____. [4 marks]

Solution:

Concept:

- The greatest integer function $[t] = \lfloor t \rfloor$ is the largest integer not exceeding t. Just below an integer n, its value is $n - 1$; just above n, its value is n.
- A two-sided limit exists when the finite left-hand and right-hand limits are equal. Since $b \in \mathbf{N}$, the number $4 + b$ is an integer.

Step 1: Find the left-hand limit Write $x = 4 - h$, where $h > 0$ tends to zero. Then $5x - 4 = 16 - 5h$. For $0 < h < 1/5$, this lies strictly between 15 and 16, so its greatest integer is 15. Hence

$$\lim_{x \to 4^-} f(x) = 15.$$

Step 2: Find the right-hand limit Write $x = 4 + h$, where $0 < h < 1$. The argument of the greatest integer is $x + b = 4 + b + h$, between the consecutive integers $4 + b$ and $5 + b$. Consequently $[x + b] = 4 + b$ throughout this small right-hand interval, and

$$\lim_{x \to 4^+} f(x) = \frac{4 + b}{2}.$$

Step 3: Equate the limits and check the result The required limit exists precisely when

$$15 = \frac{4 + b}{2} \quad \Longrightarrow \quad 30 = 4 + b \quad \Longrightarrow \quad b = 26.$$

This is a natural number. With this value, the left branch equals 15 immediately to the left of 4 and the right branch equals $30/2 = 15$ immediately to its right. A function need not be defined at 4 itself for its limit there to exist. Directly replacing x by 4 inside the left floor would give 16 and would miss

the jump; the approach direction matters.

Step 4: Conclusion The required value is $\boxed{b = 26}$, and the common limit is 15. The parameter is dimensionless.

Quick Tip to Solve: At an integer threshold, inspect which side the floor argument approaches from: $[16 - \varepsilon] = 15$, whereas $[30 + \varepsilon] = 30$ for small positive ε.

23. If $S = \{x \in [0, 4\pi] : \sin 2x - \cos x = 0\}$ and the sum of the elements of S is $k\pi$, then k is equal to _____. [4 marks]

Solution:

Concept:

- The double-angle identity $\sin 2x = 2 \sin x \cos x$ converts the equation into a product of simple factors.
- A product is zero when at least one factor is zero. List each solution in the specified closed interval and count a shared root only once.

Step 1: Factor the equation and solve the first factor Using the double-angle identity,

$$\sin 2x - \cos x = \cos x(2 \sin x - 1) = 0.$$

Thus either $\cos x = 0$ or $\sin x = 1/2$. Do not divide by cosine, since doing so would discard valid roots. In $[0, 4\pi]$, the cosine roots are

$$\frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2}.$$

Their sum is $(1 + 3 + 5 + 7)\pi/2 = 8\pi$. Neither interval endpoint is a cosine root.

Step 2: List the second family and add the roots The solutions of $\sin x = 1/2$ in the first revolution are $\pi/6$ and $5\pi/6$. Adding 2π gives the other two roots within the required interval:

$$\frac{\pi}{6}, \frac{5\pi}{6}, \frac{13\pi}{6}, \frac{17\pi}{6}.$$

Their sum is $(1 + 5 + 13 + 17)\pi/6 = 6\pi$. These four roots are distinct from the cosine roots, since a cosine root has sine equal to either 1 or -1, never 1/2. Consequently the sum of all eight distinct elements of S is $8\pi + 6\pi = 14\pi$. The endpoints 0 and 4π fail the original equation, so no boundary root needs adding.

Step 3: Conclusion Comparing the root sum 14π with $k\pi$ gives $\boxed{k = 14}$, a dimensionless integer.

Quick Tip to Solve: Factor before dividing by a trigonometric function. List roots over one full revolution, then add 2 pi to cover the second revolution.

24. If the mean of the numbers $-7, -5, -2, x, 5$ is -1, then the variance of the numbers $x-3, 4x, x+3$ is _____. [4 marks]

Solution:

Concept:

- The arithmetic mean of n observations is their sum divided by n; here the first set has five observations.
- The variance of observations $y_1, \ldots, y_n$ is $\frac{1}{n}\sum(y_i - \bar{y})^2$, equivalently $\frac{1}{n}\sum y_i^2 - \bar{y}^2$. This is the population variance, with divisor n.

Step 1: Recover the unknown observation The first five numbers have mean -1, so their sum is $5(-1) = -5$. Therefore

$$\frac{-7-5-2+x+5}{5} = -1, \qquad \frac{x-9}{5} = -1.$$

Multiplying by five gives $x - 9 = -5$, hence $x = 4$. Check: $-7-5-2+4+5 = -5$, as required. The requested variance concerns a new three-number set; the original mean -1 must not be reused for this new set.

Step 2: Calculate the variance of the new set Substituting $x = 4$, the three observations are

$$x-3 = 1, \qquad 4x = 16, \qquad x+3 = 7.$$

Their mean is $\bar{y} = (1+16+7)/3 = 8$. The deviations from this mean are -7, 8, and -1, whose sum is zero. Thus

$$\text{Var} = \frac{(-7)^2 + 8^2 + (-1)^2}{3} = \frac{49+64+1}{3} = 38.$$

The equivalent second-moment check gives $(1+256+49)/3 - 8^2 = 102 - 64 = 38$. Dividing by two instead of three would calculate a sample estimate rather than the variance requested in this elementary statistics question.

Step 3: Conclusion The variance of $x-3, 4x, x+3$ is $\boxed{38}$. The observations are dimensionless, so the variance is dimensionless as well.

Quick Tip to Solve: Find x from the original mean first, then compute a fresh mean for the transformed observations before taking squared deviations.

25. If the equation of a plane P passing through the point $\hat{i}+\hat{j}+\hat{k}$ is $\vec{r}\cdot(2\hat{i}-\hat{j}+a\hat{k}) = 3$, then the length of the perpendicular from the point $4\hat{i}-\hat{j}+3\hat{k}$ on the plane P is _____. [4 marks]

Solution:

Concept:

- A point lies on a plane when its Cartesian coordinates satisfy the plane equation. The vector multiplying $\vec{r}$ is normal to that plane.
- For $Ax+By+Cz+D=0$, the perpendicular distance of (x_0, y_0, z_0) is $d = |Ax_0 + By_0 + Cz_0 + D|/\sqrt{A^2+B^2+C^2}$. The absolute value gives a nonnegative length.

Step 1: Determine the coefficient from the given point The position vector $\hat{i}+\hat{j}+\hat{k}$ represents $(1,1,1)$. Substitute these coordinates into the plane, rather than treating a as an independent free parameter:

$$2(1)-(1)+a(1)=3 \quad \Longrightarrow \quad a=2.$$

Thus the plane has a definite normal vector $\vec{n}=2\hat{i}-\hat{j}+2\hat{k}$.

Step 2: Write the Cartesian equation and normal length The scalar-product equation now becomes

$$2x-y+2z-3=0.$$

Its coefficients, including the negative coefficient of y, must be used with their signs. The length of the normal vector is

$$|\vec{n}|=\sqrt{2^2+(-1)^2+2^2}=\sqrt{9}=3.$$

Dividing by this length converts the algebraic plane expression into an actual perpendicular distance.

Step 3: Evaluate the perpendicular distance The second position vector gives $Q=(4,-1,3)$. In particular, the negative value of y contributes positively to $-y$:

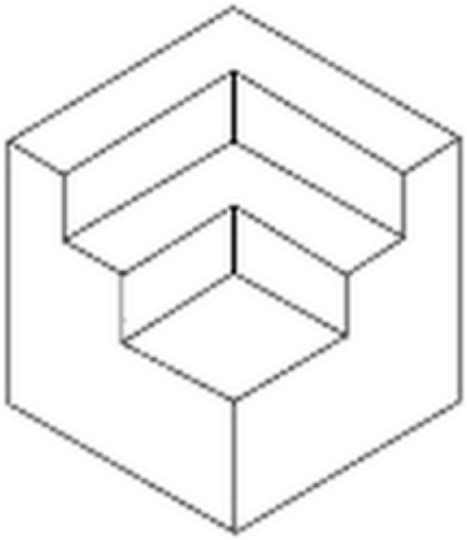
$$d=\frac{|2(4)-(-1)+2(3)-3|}{3}=\frac{|8+1+6-3|}{3}=\frac{12}{3}=4.$$

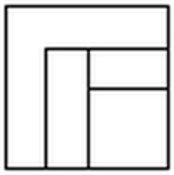
As a check, the foot is $Q-\frac{12}{9}(2,-1,2)=(4/3,1/3,1/3)$, which satisfies the plane equation, and the displacement from it to Q is parallel to the normal.

Step 4: Conclusion The required length of the perpendicular is $\boxed{4}$ units.

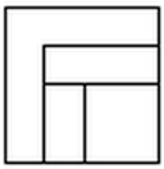
Quick Tip to Solve: First use the point lying on the plane to determine its unknown coefficient; only then apply the distance formula, retaining the minus sign before y.

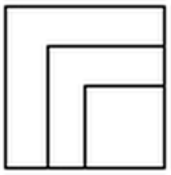
26. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

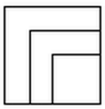


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In an orthographic top view, vertical height is suppressed. Parallel horizontal edges of the isometric object become perpendicular directions in the plan.
- Keep the outside footprint and the boundaries between visible horizontal surfaces at different levels. Do not add a line merely because a vertical face has an edge hidden below another surface.

Step 1: Trace the complete outside footprint Look vertically down on the whole object. Its outside plan is a square: the two sloping isometric directions become its horizontal and vertical sides. The outside vertical faces determine the limiting boundary but their heights do not make extra strips in the plan. All four proposed figures have the square outline, so the internal visible step edges are decisive.

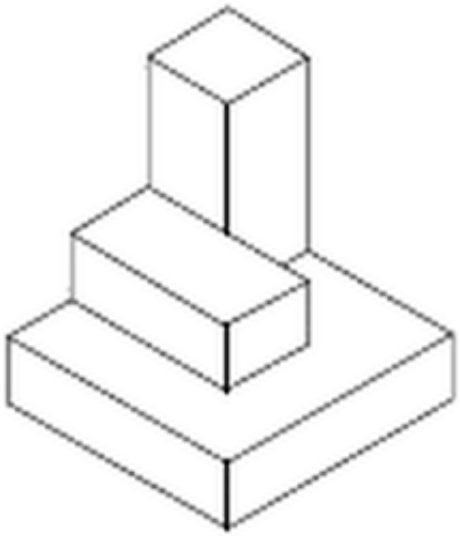
Step 2: Follow the two recessed corners The upper horizontal rim runs along two adjacent outer sides. Its inner edge turns through a right angle, making one continuous L inside the outer square. The next lower ledge repeats that corner farther inward. Its edge makes a second, smaller nested L. Both corners open in the same direction; neither ledge is subdivided into a succession of independent rectangular cells. The innermost floor occupies the remaining corner region.

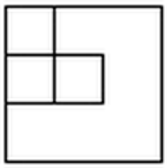
Step 3: Eliminate the extra partitions Option (D) preserves exactly these two nested L-shaped step boundaries. Option (A) extends the inner vertical line to the upper internal horizontal boundary and inserts a cross-partition. Option (B) introduces a full vertical strip extending from the outer top edge to the bottom. Option (C) places a complete horizontal subdivision across the inner region. Those added edges have no corresponding visible change of level in the object, so they cannot appear in its top view.

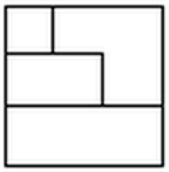
Step 4: Conclusion The top view contains the square outline and two nested L-shaped boundaries. Hence, the correct option is (D).

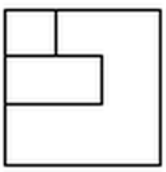
Quick Tip to Solve: For a recessed corner, trace each horizontal ledge continuously around the corner. Its plan boundary is an L, not a grid of separate boxes.

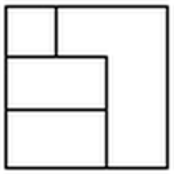
27. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

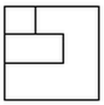


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- In an orthographic top view, vertical height is suppressed. Parallel horizontal edges of the isometric object become perpendicular directions in the plan.
- Keep the outside footprint and the boundaries between visible horizontal surfaces at different levels. Do not add a line merely because a vertical face has an edge hidden below another surface.

Step 1: Identify the footprint and upper components The broad bottom slab establishes a square outside footprint. Above it are a rectangular horizontal block and a taller square column at its rear corner. Looking from above removes their different heights but retains the edges where one visible horizontal surface meets the projection of a higher component. Begin with the outline of the base and then place these two upper footprints.

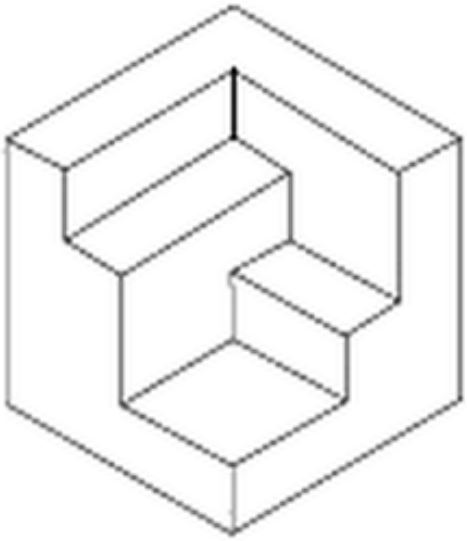
Step 2: Locate the visible internal boundaries The tall column contributes a small square in the upper left of the plan. Its right edge stops at the edge of the rectangular step immediately in front of it. That step occupies a rectangle extending farther right than the column, with a horizontal lower edge and a vertical short right edge. The base remains visible as one surrounding L-shaped region. The vertical side edges below the top of the step do not continue through this exposed base region.

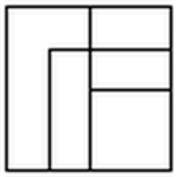
Step 3: Compare the line endings in the options Option (C) shows the small upper-left square and the projecting rectangle beneath it, with the remaining base as an undivided L. Option (A) wrongly carries the column subdivision down through the rectangular step. Option (B) extends the step lower edge across the full base width. Option (D) adds a vertical continuation down to the bottom boundary and subdivides the exposed base. These spurious seams do not correspond to visible upper edges.

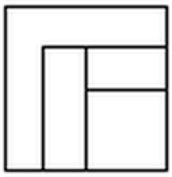
Step 4: Conclusion The square column and rectangular step project as shown in (C). Hence, the correct option is (C).

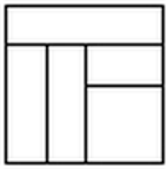
Quick Tip to Solve: Check where each internal line stops: a vertical face edge below the topmost visible surface must not be extended across the base in plan.

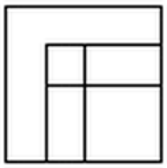
28. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- In an orthographic top view, vertical height is suppressed. Parallel horizontal edges of the isometric object become perpendicular directions in the plan.
- Keep the outside footprint and the boundaries between visible horizontal surfaces at different levels. Do not add a line merely because a vertical face has an edge hidden below another surface.

Step 1: Project the outer rim before the interior The outer body has a square footprint. Its uppermost horizontal rim follows two adjacent sides around the rear corner. In plan that rim gives one continuous L-shaped band, of consistent width, rather than a full-width horizontal band detached from its perpendicular arm. Height is irrelevant to the width of this band when seen directly overhead.

Step 2: Trace the lower platform boundaries Inside the rim the stepped surfaces are not two identical nested corners. A lower raised region extends down one side, and a horizontal step boundary runs

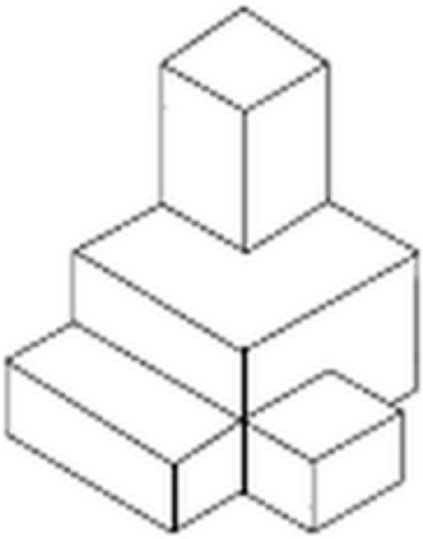
from that inner vertical boundary to the right edge at an intermediate position. The inner vertical begins at the rim boundary rather than at the outside top edge. The result is an L-shaped outer band with a smaller inner corner whose right-hand area is divided once horizontally.

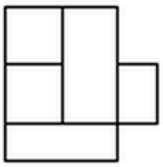
Step 3: Reject lines unsupported by the solid Option (B) has precisely this arrangement: the top rim joins its left arm, the next inner vertical starts at the inner corner, and the horizontal division runs to the right. Option (A) continues a vertical line up through the top rim and adds an extra division. Option (C) makes the top strip span the whole width in a way that interrupts the rim turn and extends an inner line down. Option (D) adds a cross-line through the narrow inner strip. Each changes the visible level boundaries.

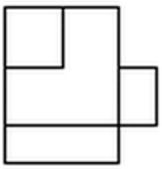
Step 4: Conclusion The correct projection is the L-shaped rim with the intermediate right-hand step in (B). Hence, the correct option is (B).

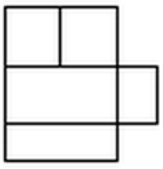
Quick Tip to Solve: Preserve each rim as a connected band first; then add lower step boundaries only where their upper horizontal surfaces remain visible.

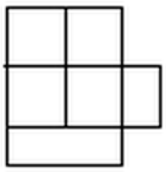
29. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

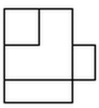


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- In an orthographic top view, vertical height is suppressed. Parallel horizontal edges of the isometric object become perpendicular directions in the plan.
- Keep the outside footprint and the boundaries between visible horizontal surfaces at different levels. Do not add a line merely because a vertical face has an edge hidden below another surface.

Step 1: Determine the outline from all exposed pieces The main slab has a rectangular footprint, with a lower piece extending on the right. The left-front lower piece remains within the overall width of the main footprint but contributes the visible bottom band. The complete plan therefore has a rectangular main outline and a short rectangular projection to its right. The column cannot enlarge that outside outline because it sits wholly on the upper slab.

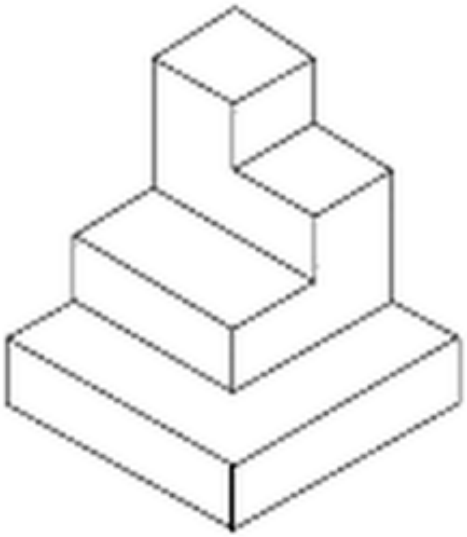
Step 2: Place the upper column and exposed lower ledges The top of the tall column is a small square at the upper-left corner of the main slab in the stated plan orientation. Only the right and lower sides of this square appear as internal boundaries: its other sides coincide with the outside upper-left limits. The remainder of the upper slab is one continuous visible surface. A horizontal boundary near the bottom separates that slab from the exposed lower ledge, and the offset right-hand extension remains visible beside it.

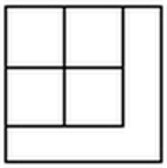
Step 3: Eliminate divisions across continuous surfaces Option (B) preserves the small upper-left square, the uninterrupted remaining slab, the lower band and the right extension. Option (A) adds a long vertical divider below the column and divides the slab into separate strips. Option (C) extends the column lower edge across the entire main slab. Option (D) combines a full horizontal continuation with a long vertical continuation. These lines would divide a horizontal surface which is continuous in the object and are therefore incorrect.

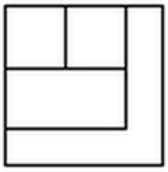
Step 4: Conclusion The continuous upper slab and the isolated corner-column footprint match (B). Hence, the correct option is (B).

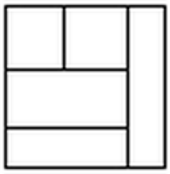
Quick Tip to Solve: After locating a column footprint, stop its boundary at the column itself; do not continue that line across the supporting slab.

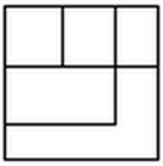
30. The 3 - D figure shows the view of an object. Identify the correct top view from amongst the answer figures. [4 marks]

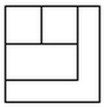


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- In an orthographic top view, vertical height is suppressed. Parallel horizontal edges of the isometric object become perpendicular directions in the plan.
- Keep the outside footprint and the boundaries between visible horizontal surfaces at different levels. Do not add a line merely because a vertical face has an edge hidden below another surface.

Step 1: Separate the base from the raised footprint The bottom slab sets a square outside boundary. The raised assembly leaves a visible L-shaped band along the front and one side of this base. Consequently the plan must retain an inset boundary along those exposed base surfaces. The two higher levels are both contained inside this raised footprint; their vertical risers affect the location of boundaries but do not add thickness in the top view.

Step 2: Trace the two uppermost horizontal surfaces At the rear of the raised footprint, the highest

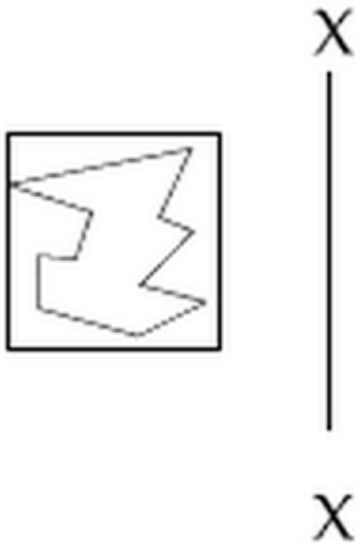
square top and the adjacent lower square top lie next to one another in plan. Their common boundary makes a short vertical line in the upper band. That line ends at the front edge of these two top surfaces. In front of them is the broad rectangular surface of the next lower step, which must stay uninterrupted across its width. Its right edge stops above the front strip of the base.

Step 3: Use the unbroken middle rectangle to choose Option (B) shows two small upper rectangles, one broad middle rectangle, and the exposed L-shaped base region. Option (A) extends the upper divider through the middle platform, incorrectly creating a grid. Option (C) carries the inner right boundary to the outside bottom edge instead of stopping at the platform. Option (D) places the upper divider into the side strip and extends another internal edge downward. These extra seams disagree with the visible rectangular surfaces of the solid.

Step 4: Conclusion The plan with two upper cells above one unbroken rectangular platform is (B). Hence, the correct option is (B).

Quick Tip to Solve: Group visible horizontal surfaces by level and outline each footprint. A divider between two upper tops should end where both tops end.

31. 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: (C) 

Solution:

Concept:

- A plane mirror placed along the vertical line $X - X$ reverses left and right. Heights and vertical distances remain unchanged.
- Reflection preserves lengths, angles and connections. For a mirror at $x = a$, a point (x, y) maps to $(2a - x, y)$; the figure is not rotated.

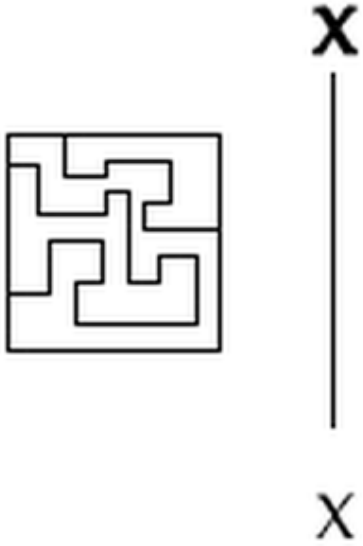
Step 1: Reflect distinctive features The pointed end that touches the left side of the problem square must touch the right side after reflection. The two angular teeth on the right of the original must appear on the left, at the same respective heights. The small rectangular recess on the original left therefore moves to the right. Follow the outline continuously, retaining every inward and outward corner. A top corner remains at the top, even though its horizontal position changes.

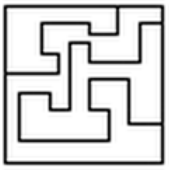
Step 2: Compare all four answer figures Option (C) has the required pointed upper-right end, the pair of angular projections on the left, and the rectangular step at the right. Option (A) changes the upper-right recess into a diagonal edge. Option (B) changes the lower-left outline, losing the second outward tooth. Option (D) replaces the stepped right-hand contour by a bent, nearly continuous contour. Each candidate must satisfy all of these checks at once; agreement at one isolated corner does not establish a complete mirror image.

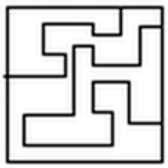
Step 3: Conclusion The figure in option (C) is the left-right reflection of the problem figure about the vertical line $X - X$. Hence, the correct option is (C).

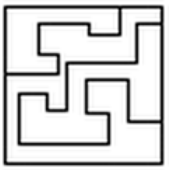
Quick Tip to Solve: Start with an asymmetric notch or projection, move it to the opposite side at the same height, and then trace the entire connected outline to reject near matches.

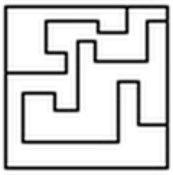
32. Which one of the answer figures is the correct mirror image of the problem figure with respect to X - X ? [4 marks]

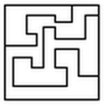


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A plane mirror placed along the vertical line $X - X$ reverses left and right. Heights and vertical distances remain unchanged.
- Reflection preserves lengths, angles and connections. For a mirror at $x = a$, a point (x, y) maps to $(2a - x, y)$; the figure is not rotated.

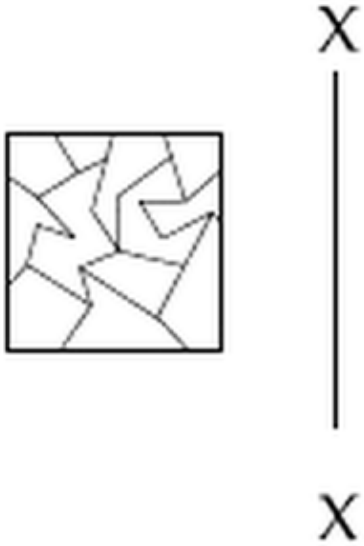
Step 1: Reflect distinctive features Read the top boundary first. The short vertical segment joining the upper edge near the left of the original must join it near the right in the reflection. The narrow upper passage then bends towards the left. At the bottom, the long horizontal run retains its height, while its upright ends exchange sides. Follow the outline continuously, retaining every inward and outward corner. A top corner remains at the top, even though its horizontal position changes.

Step 2: Compare all four answer figures Option (A) reproduces both the upper stepped path and the lower rectangular path. In option (B), the lower-left return runs straight across where the reflected path needs an inward step. Option (C) alters the little upper notch and its vertical connection. Option (D) changes the lower-right stepped portion into a long vertical return. These are changes of shape, rather than left-right reflection. Each candidate must satisfy all of these checks at once; agreement at one isolated corner does not establish a complete mirror image.

Step 3: Conclusion The figure in option (A) is the left-right reflection of the problem figure about the vertical line $X - X$. Hence, the correct option is (A).

Quick Tip to Solve: Start with an asymmetric notch or projection, move it to the opposite side at the same height, and then trace the entire connected outline to reject near matches.

33. 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 plane mirror placed along the vertical line $X - X$ reverses left and right. Heights and vertical distances remain unchanged.
- Reflection preserves lengths, angles and connections. For a mirror at $x = a$, a point (x, y) maps to $(2a - x, y)$; the figure is not rotated.

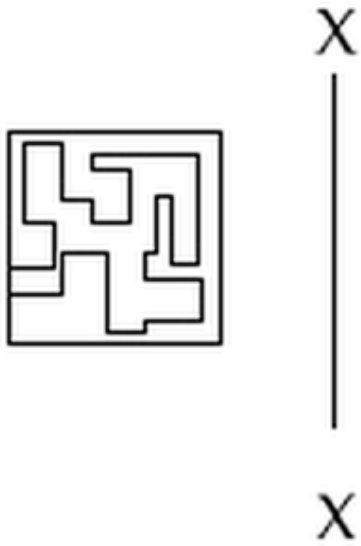
Step 1: Reflect distinctive features Use the central junction and follow each connected line towards the square boundary. The narrow angular strip which originally rises to the right of the centre must rise to the left after reflection. The large triangular region at the bottom right of the original moves to the bottom left, with the same sloping edge and the same junction. Follow the outline continuously, retaining every inward and outward corner. A top corner remains at the top, even though its horizontal position changes.

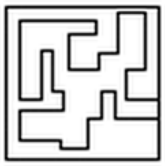
Step 2: Compare all four answer figures Option (D) preserves the central junction, the upper-left narrow strip and the large lower-left triangular region simultaneously. Option (A) changes the angle and connection at the central junction. Option (B) puts an extra long sloping line across the central left-hand region. Option (C) changes the lower-left region into a bent polygon rather than retaining the diagonal triangle. Thus matching only the outer square is insufficient. Each candidate must satisfy all of these checks at once; agreement at one isolated corner does not establish a complete mirror image.

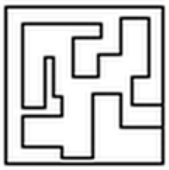
Step 3: Conclusion The figure in option (D) is the left-right reflection of the problem figure about the vertical line $X - X$. Hence, the correct option is (D).

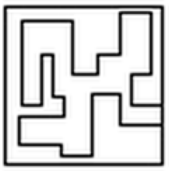
Quick Tip to Solve: Start with an asymmetric notch or projection, move it to the opposite side at the same height, and then trace the entire connected outline to reject near matches.

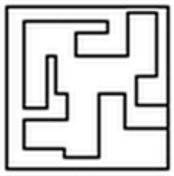
34. Which one of the answer figures is the correct mirror image of the problem figure with respect to X - X ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A plane mirror placed along the vertical line $X - X$ reverses left and right. Heights and vertical distances remain unchanged.
- Reflection preserves lengths, angles and connections. For a mirror at $x = a$, a point (x, y) maps to $(2a - x, y)$; the figure is not rotated.

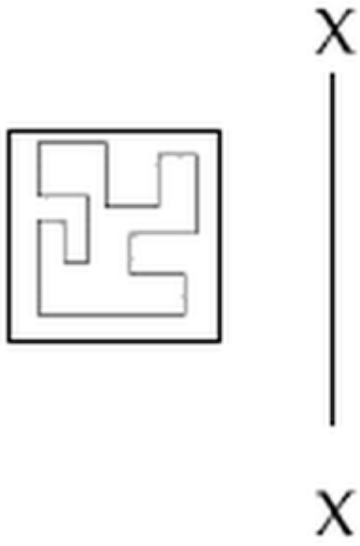
Step 1: Reflect distinctive features The long vertical return near the right boundary of the original becomes the long return near the left boundary. The upper-left rectangular loop moves to the upper right. Next trace the low horizontal run: its small downward step must exchange sides without changing its height. The broad inward rise from the bottom appears on the right of centre. Follow the outline continuously, retaining every inward and outward corner. A top corner remains at the top, even though its horizontal position changes.

Step 2: Compare all four answer figures Option (B) has the required upper notch, long left return, small step along the bottom and broad central rise. Option (A) introduces an additional staircase in the lower central portion. Option (C) omits the horizontal notch in the upper path. Option (D) makes the upper central recess too shallow and changes its connection. The complete sequence of right-angle bends, rather than the general outline alone, selects (B). Each candidate must satisfy all of these checks at once; agreement at one isolated corner does not establish a complete mirror image.

Step 3: Conclusion The figure in option (B) is the left-right reflection of the problem figure about the vertical line $X - X$. Hence, the correct option is (B).

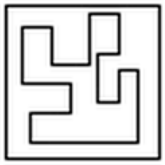
Quick Tip to Solve: Start with an asymmetric notch or projection, move it to the opposite side at the same height, and then trace the entire connected outline to reject near matches.

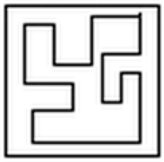
35. Which one of the answer figures is the correct mirror image of the problem figure with respect to X - X ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A plane mirror placed along the vertical line $X - X$ reverses left and right. Heights and vertical distances remain unchanged.
- Reflection preserves lengths, angles and connections. For a mirror at $x = a$, a point (x, y) maps to $(2a - x, y)$; the figure is not rotated.

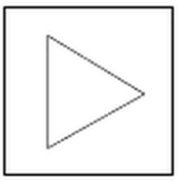
Step 1: Reflect distinctive features The tall rectangular projection on the upper left of the original moves to the upper right. Its broad top must remain broad. The narrow downward indentation near the upper right moves to the upper left. The low long horizontal run remains low, and the short narrow vertical notch in the original left part moves into the right part. Follow the outline continuously, retaining every inward and outward corner. A top corner remains at the top, even though its horizontal position changes.

Step 2: Compare all four answer figures Option (D) retains the wide upper-right rectangular projection and the narrow right-hand indentation, together with the long lower run. Option (A) removes the narrow right-hand indentation. Option (B) changes the height and shape of the upper-left return. Option (C) makes the upper-right projection narrow instead of broad. Line darkness is irrelevant: compare positions and connections, not the weight of the printed stroke. Each candidate must satisfy all of these checks at once; agreement at one isolated corner does not establish a complete mirror image.

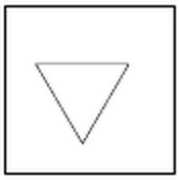
Step 3: Conclusion The figure in option (D) is the left-right reflection of the problem figure about the vertical line $X - X$. Hence, the correct option is (D).

Quick Tip to Solve: Start with an asymmetric notch or projection, move it to the opposite side at the same height, and then trace the entire connected outline to reject near matches.

36. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An odd-one-out comparison identifies a geometrical property shared by three figures and absent in the fourth.
- Rotation changes the direction in which a triangle points, while uniform enlargement changes its size. Neither operation changes its angles or the ratio of its side lengths.

Step 1: Identify the common triangular shape Compare the triangles inside the squares, setting aside their orientation and overall size. In (A), the triangle points to the right and has approximately equal sides. In (B), a smaller triangle points upwards but retains the same equilateral proportions. In (C), the triangle points downwards and again has equal-sided proportions. Their common property is an equilateral triangle, whose three angles are each approximately 60°.

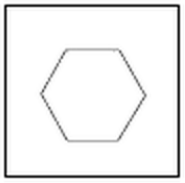
Step 2: Test the remaining figure against that property In (D), the upright triangle is visibly taller relative to its horizontal base. Its two sloping sides are equal to one another, but each is longer than its base. It is therefore a non-equilateral isosceles triangle. The difference cannot be removed by rotating it or uniformly changing its size. Option (A) is not odd merely because it points sideways; (B) is not odd merely because it is small; and (C) is not odd merely because it points downwards. Those changes preserve the equilateral shape shared by the first three figures.

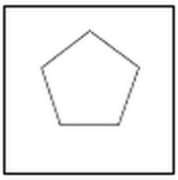
Step 3: Conclusion The non-equilateral isosceles triangle is the odd figure; the other three triangles have equilateral proportions. Hence, the correct option is (D).

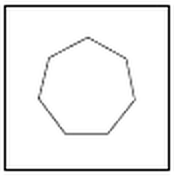
Quick Tip to Solve: Ignore direction and size initially. Compare side ratios or angles to distinguish a true change of shape from a rotation or enlargement.

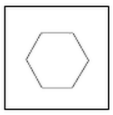
37. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An odd-figure problem asks for the property shared by three figures and violated by exactly one. The number of sides is preserved when a polygon is turned, enlarged or moved.
- Classify a polygon by tracing its boundary once and counting each straight edge. The surrounding square is a common frame and is not the polygon being compared.

Step 1: Count the inner polygon sides Begin at the top vertex of each inner shape and trace its boundary clockwise back to the starting point. Figure (A) is a triangle with 3 sides; figure (B) is a hexagon with 6 sides; figure (C) is a pentagon with 5 sides; and figure (D) is a heptagon with 7 sides. Count the sloping edges separately rather than estimating the size of the shape.

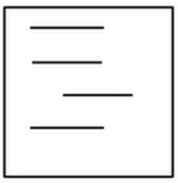
Step 2: Compare parity across all four figures The side counts are 3, 6, 5 and 7 respectively. The triangle, pentagon and heptagon all have an odd number of sides. Six is even, so the hexagon alone fails the common odd-sided property. This classification groups three figures together, rather than singling out the triangle merely because it has the fewest edges.

Step 3: Eliminate the remaining options Options (A), (C) and (D) each satisfy the same odd-side test and therefore cannot be the exceptional member under this rule. All four shapes are closed polygons inside square frames, so being closed or having a surrounding square does not distinguish any one of them. Their different sizes also do not affect their side counts.

Step 4: Conclusion The hexagon in (B) is the only inner polygon with an even number of sides. Hence, the correct option is (B).

Quick Tip to Solve: Ignore the common outer frame; count the edges of each inner polygon and test odd versus even before comparing its orientation.

38. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- The number of separate repeated elements is a useful invariant in an odd-figure test. Moving a line sideways does not change the number of lines in a figure.
- Compare the horizontal strokes inside the frame, excluding the four sides of the square border. A valid distinguishing rule should include three options and exclude only one.

Step 1: Count the horizontal strokes Scan each frame from top to bottom so that no stroke is counted twice. Option (A) contains four separate horizontal strokes, option (B) also contains four, and option (C) contains four. Option (D), in contrast, contains five horizontal strokes. The lower two strokes on the right in (D) are separate and must both be included.

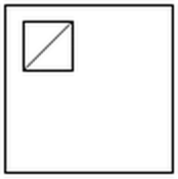
Step 2: Separate count from position The strokes in (A), (B) and (C) are shifted left or right in different rows, but each figure still has exactly four strokes. These lateral shifts do not create additional strokes or join existing ones. In (D), the extra lower stroke changes the count itself. Thus the relevant difference is a discrete extra element, rather than a difference in spacing.

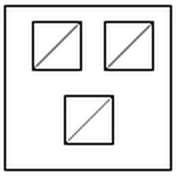
Step 3: Check the exceptional option against the group The shared property of (A), (B) and (C) is therefore four internal horizontal lines. None of these three can be the odd member on this criterion. Option (D) violates that property by having five. Counting the square border would add the same features to every option and would obscure the simple comparison of the intended internal pattern.

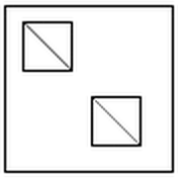
Step 4: Conclusion Figure (D) has five internal horizontal strokes, whereas each other figure has four. Hence, the correct option is (D).

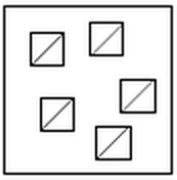
Quick Tip to Solve: Count from top to bottom and exclude the frame. Differences in left-right placement can distract from a simple extra-stroke pattern.

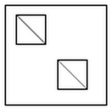
39. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- An odd figure can be identified by a common count property or by a consistent orientation of its repeated motifs. Check that the same rule applies to all three non-exceptional options.
- For a square motif, distinguish a diagonal rising from lower left to upper right from one falling from upper left to lower right. Translation of the motif does not reverse that slope.

Step 1: Inspect the square motifs and their diagonals Option (A) has one small square, (B) has three small squares and (D) has five small squares. In all three, every drawn diagonal rises from the lower-left corner to the upper-right corner of its small square. Option (C) has two small squares, and their diagonals instead run from the upper-left corner to the lower-right corner.

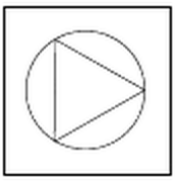
Step 2: Apply a common rule to the three matching figures The counts in (A), (B) and (D) are 1, 3 and 5, which are all odd. Their diagonals also have the same upward slope when read from left to right. Option (C) is exceptional under both checks: its count is even and its diagonals have the opposite slope. These are directly visible features, independent of where each small square lies within the frame.

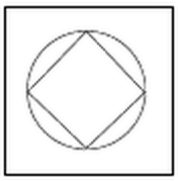
Step 3: Eliminate the other figures consistently Choosing (A) merely because it contains the fewest squares would overlook the common orientation and odd-count pattern. Options (B) and (D) likewise belong with (A), despite containing more copies of the motif. The outer square frame is common to every option and does not distinguish them. The two-square figure in (C) is the only one outside the shared group.

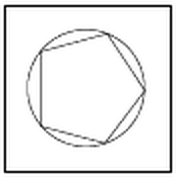
Step 4: Conclusion Figure (C) alone has an even number of small squares and oppositely sloping diagonals. Hence, the correct option is (C).

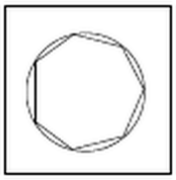
Quick Tip to Solve: Check the direction of repeated diagonals as well as the number of motifs; two independent matching properties can confirm the odd figure.

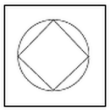
40. Find the odd figure out of the problem figures given below. [4 marks]

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A polygon can be classified by its number of straight sides. Whether that number is odd or even is unchanged by rotating the polygon within its surrounding circle.
- For an odd-figure comparison, distinguish the straight polygon edges from the curved circumference. The circle and square frame are common features of all four options.

Step 1: Trace and count the polygon boundaries Within (A), the three straight chords form a triangle. Within (B), four straight sides form a quadrilateral drawn like a diamond. Within (C), five straight sides form a pentagon. Within (D), seven straight sides form a heptagon; trace each short sloping edge around its perimeter rather than treating adjacent edges as a single curve.

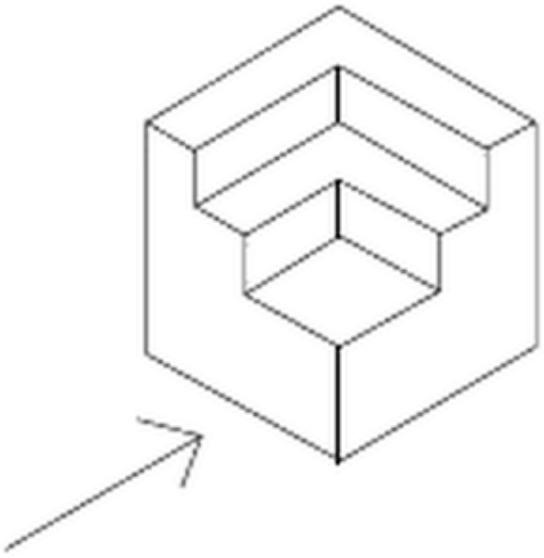
Step 2: Find the property shared by three options The polygon side counts are therefore 3, 4, 5 and 7. The triangle, pentagon and heptagon have odd side counts, while the quadrilateral has an even side count. The apparent diamond orientation in (B) is simply a rotation of a four-sided figure; it does not change the count from four.

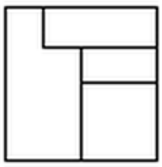
Step 3: Rule out irrelevant differences Options (A), (C) and (D) all satisfy the odd-sided rule, so they form the matching group. All four contain a polygon within a circle and a square frame, making those enclosing shapes unhelpful for the distinction. A rule based only on increasing counts would not capture the actual common property of three figures; parity does so immediately and uniquely.

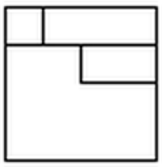
Step 4: Conclusion The four-sided polygon in (B) is the only even-sided polygon; the others have 3, 5 and 7 sides. Hence, the correct option is (B).

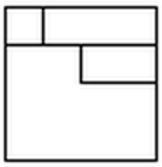
Quick Tip to Solve: Count the straight sides, then test parity. A rotated square remains four-sided even when it is drawn as a diamond.

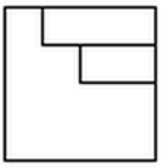
41. The 3 - D figure shows the view of an object. Identify the correct front view in the direction of the arrow, from amongst the answer figures. [4 marks]

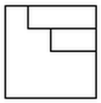


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- A front view is an orthographic projection along the indicated arrow: depth is suppressed, but horizontal position and height remain. Sloping edges in the pictorial view need not remain sloping in the elevation.
- Draw a visible edge only where the projected surface has an actual boundary or change of level. An edge behind an opaque front surface must not be shown as a continuous visible line.

Step 1: Fix the viewing direction and outer outline Look along the arrow towards the object, keeping the upright edges vertical. The full outside silhouette projects as a square. The stepped recess is visible in the upper and right-hand portions of this outline, while the lower front region is one uninterrupted solid face. The depth direction collapses in this view, so the isometric slants are not copied into the front elevation.

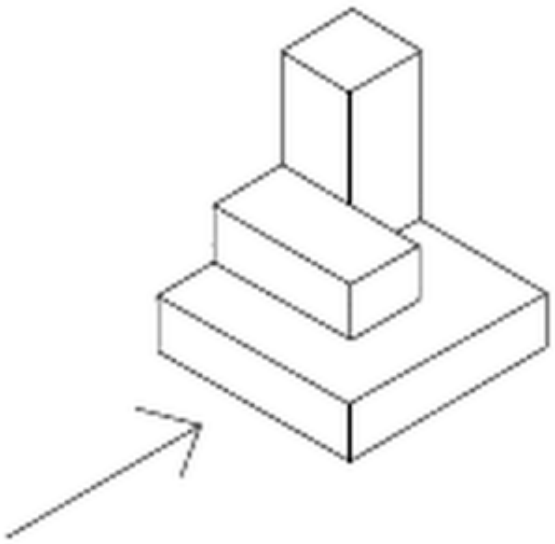
Step 2: Track the two recessed levels Follow the visible change of level from the upper part of the left rim. It produces a short vertical drop below the top edge, followed by a horizontal edge extending to the right boundary. The next recessed level starts farther right, with another short vertical drop and a second horizontal edge extending to the right. Together these form a descending stepped internal boundary, as in (D).

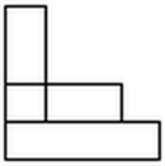
Step 3: Reject edges that the projection does not expose Option (A) carries the central vertical division down to the bottom edge, incorrectly splitting the lower uninterrupted face. Options (B) and (C) extend the upper internal horizontal line all the way to the left outside edge, adding a line across the solid left rim. The required view instead leaves that short left strip unbroken, while retaining the two rightward horizontal ledges. Only (D) has this combination of outer silhouette and visible internal steps.

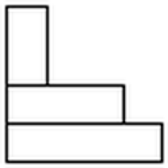
Step 4: Conclusion The projected outline and the visible two-step recess agree with figure (D). Hence, the correct option is (D).

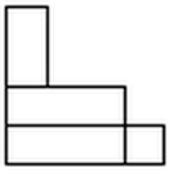
Quick Tip to Solve: Trace the solid front rim before the recessed edges. Do not extend a terrace boundary through an opaque strip merely to complete a horizontal line.

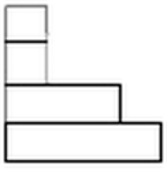
42. The 3 - D figure shows the view of an object. Identify the correct front view in the direction of the arrow, from amongst the answer figures. [4 marks]

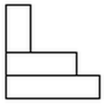


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- In an orthographic front view, looking along the arrow removes depth while preserving height and horizontal width. The visible outline is the union of all projected solid portions.
- An internal line is shown only for a visible edge or change of surface. Coplanar pieces merging in projection do not acquire an extra dividing line simply because their isometric depth edges are visible.

Step 1: Project the outside silhouette The object consists of a broad low base, a narrower raised rectangular block and a tall narrow column behind the left portion. Viewed along the arrow, these give three heights arranged from left to right: the tall column, the middle-level block and the low base. Their combined outline is therefore a staircase descending towards the right, with three horizontal top levels.

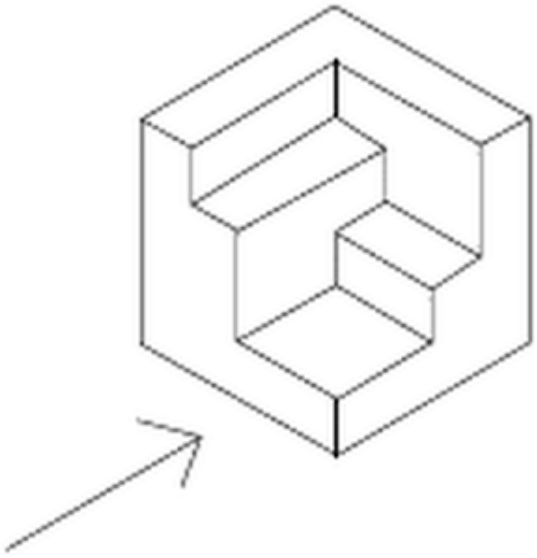
Step 2: Preserve the visible level boundaries The top of the base produces a horizontal boundary across the width above the lowest strip, and the top of the middle block produces the next horizontal boundary. The tall column rises above that middle block. Its front surface is a single uninterrupted rectangle above the middle level, so it must not be subdivided horizontally. The lower front faces likewise have no extra vertical seams continuing down from the column.

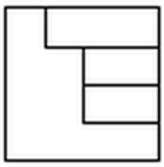
Step 3: Compare all four projected drawings Option (B) has the descending outside silhouette and the two continuous horizontal level boundaries, without false subdivisions. Option (A) extends the column-side vertical line through lower front portions. Option (C) adds a vertical line through the right end of the base strip. Option (D) inserts an extra horizontal line across the tall column. Those additional lines do not represent visible changes of surface in the required front view, so all three are rejected.

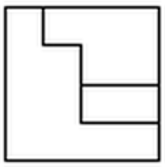
Step 4: Conclusion Figure (B) gives the correct stepped elevation without adding false seams to the front faces. Hence, the correct option is (B).

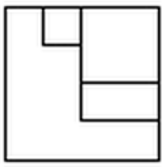
Quick Tip to Solve: First obtain the stepped silhouette, then check every internal line against a real visible edge; depth edges often disappear in the front view.

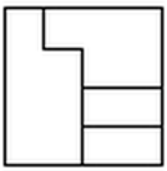
43. The 3 - D figure shows the view of an object. Identify the correct front view in the direction of the arrow, from amongst the answer figures. [4 marks]

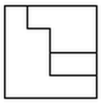


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- A front view is an orthographic projection along the indicated arrow: depth collapses, while horizontal positions and vertical heights remain.
- Only visible changes of surface or depth produce interior edges. A line cannot be continued through a region where that edge is hidden by the front surface.

Step 1: Fix the direction of observation Look into the object along the arrow from the lower left. The sloping isometric depth direction is therefore compressed in the view. The outer boundary becomes a square, so the distinction between the answers lies in the internal edges, rather than in the outline. Retain the vertical height of each step and compare the horizontal positions of the two changes in level.

Step 2: Trace the recessed steps Starting near the upper left of the projected square, the visible inner

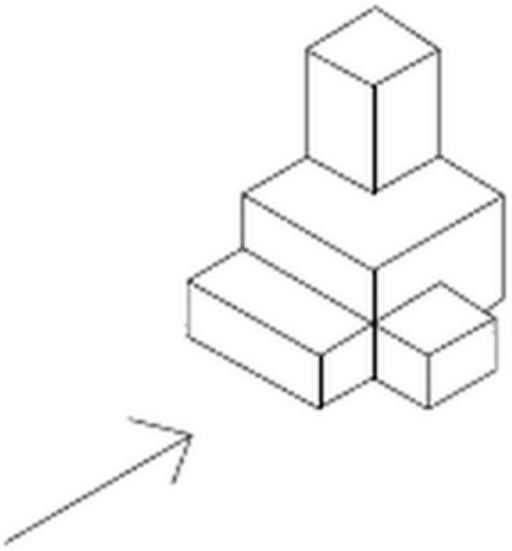
boundary drops, runs right, then drops again to form the longer vertical edge of the recess. This edge stops at the bottom of the recessed portion; it does not extend to the bottom boundary of the outer square. On its right, the visible step supplies the intermediate horizontal division. These features produce the stepped internal outline shown in (B).

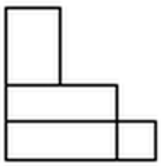
Step 3: Eliminate the other projections Option (A) draws a horizontal division across the upper right part where the outline should turn down into the recess. Option (C) replaces the bent internal boundary with a straight vertical boundary at its upper part, losing the visible offset. Option (D) continues the inner vertical edge to the outer bottom edge, incorrectly dividing a continuous lower face. Only (B) preserves both the offsets and the correct termination of the visible edges.

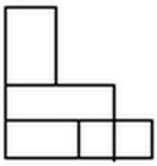
Step 4: Conclusion The required square elevation has the stepped inner boundary and the short right-hand horizontal division shown in (B). Hence, the correct option is (B).

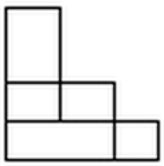
Quick Tip to Solve: For a recessed object, trace the termination of each inner edge as carefully as its position; a hidden continuation can distinguish otherwise similar elevations.

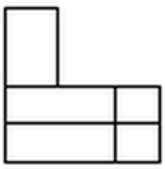
44. The 3 - D figure shows the view of an object. Identify the correct front view in the direction of the arrow, from amongst the answer figures. [4 marks]

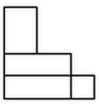


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- Orthographic elevation removes the depth parallel to the arrow but preserves the heights of the stacked portions and their left-to-right arrangement.
- A visible edge is retained only over the span of the actual change in surface. Parallel edges at different depths can project onto the same line.

Step 1: Read the three height levels The arrow asks for the view from the lower-left side of the isometric drawing. The tall upright occupies the left part of the elevation. The middle block extends farther to the right, and the low projecting block supplies the final short extension on the right. Consequently, the outside contour descends in three levels from left to right, rather than giving three separate detached rectangles.

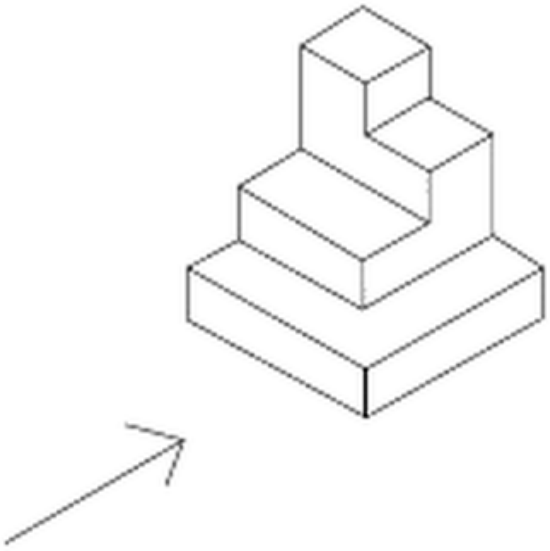
Step 2: Project the visible horizontal and vertical edges Keep the left upright as a narrow vertical rectangle above the middle level. Its right edge stops where it meets that level. Across the main body, the next visible change of height gives a horizontal line; the low right-hand projection joins the lowest band. The joint at the start of that right-hand extension appears only in the bottom band. No additional internal division is visible through the central portion of that bottom band.

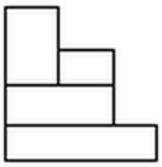
Step 3: Compare the four line arrangements Option (A) has precisely this outline, the isolated upper upright, the two continuous horizontal bands, and the short vertical joint adjoining the right extension at the base. Option (B) adds an extra vertical division inside the bottom band. Option (C) extends the upright division down through the middle band, creating an edge that should not appear there. Option (D) continues a right-hand vertical division upwards through the middle band. Those extra lines do not follow the visible surfaces from the arrow direction.

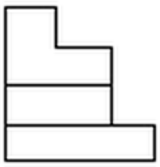
Step 4: Conclusion The front elevation is the three-level outline with the internal edges shown in (A). Hence, the correct option is (A).

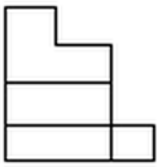
Quick Tip to Solve: After matching a stepped silhouette, check each interior vertical segment separately; depth edges may disappear or coincide in the requested elevation.

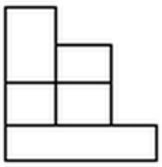
45. The 3 - D figure shows the view of an object. Identify the correct front view in the direction of the arrow, from amongst the answer figures. [4 marks]

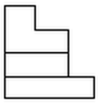


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- In a front elevation, the depth of each tread is suppressed and the staircase is described by its horizontal widths and vertical risers.
- Edges parallel to the viewing direction do not create new vertical divisions in a continuous projected front face.

Step 1: Determine the outside contour Observe the object in the arrow direction. The narrow high portion lies on the left, the intermediate height occupies the central part, and the broad base continues to the right. Its projected outline is therefore a descending staircase: the highest left portion, a lower middle portion and the low right-hand base extension. Perspective sloping lines become horizontal level boundaries in this orthographic view.

Step 2: Retain the changes of level The front-facing portions of the lower and intermediate steps give

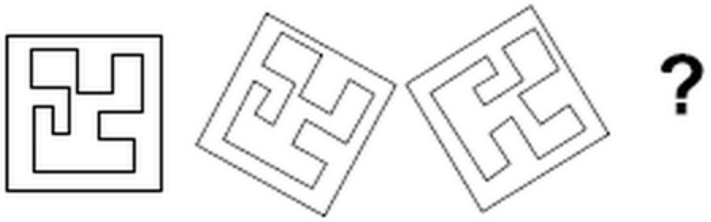
two horizontal lines across the main left-hand width. The uppermost small step changes the outside contour, but its depth edge does not divide the vertical front face into two separate columns. Likewise, the broad bottom front face remains continuous: there is no extra short vertical line at the start of the base extension.

Step 3: Reject the extra seams Option (B) shows the stepped contour with the two horizontal divisions and no unnecessary interior vertical seams. Option (A) introduces a vertical segment from the upper notch down to the first horizontal level; that treats an edge seen in depth as a front-face division. Option (C) adds a vertical division through the bottom band beside the right extension. Option (D) continues an internal vertical line through the upper and middle bands. None of these extra divisions is part of the visible front elevation. Matching the outline alone would not distinguish the choices; the absence of those seams is decisive.

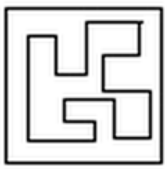
Step 4: Conclusion The elevation has a stepped outer boundary and continuous horizontal front bands, as in (B). Hence, the correct option is (B).

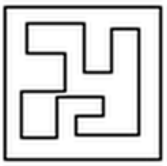
Quick Tip to Solve: For staircase solids, separate the outer height profile from the interior seams; do not copy every depth edge from the isometric drawing into the elevation.

46. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- A rotation changes orientation without changing the lengths, connections or order of the parts of a figure. Reflections reverse the handedness and are a different operation.
- The square frames successively turn clockwise through equal increments of 30°. Thus the fourth figure is the original motif rotated clockwise by 90°.

Step 1: Identify the repeated transformation Compare the outer square in the three problem figures. It starts upright, turns clockwise by approximately 30°, and then turns through another 30°. The internal motif follows the same rotation; its notches and connected branches do not exchange places independently. The continuation must therefore make one further equal clockwise turn. The total turn from the first position is $3 \times 30^\circ = 90^\circ$, so the final frame is upright again.

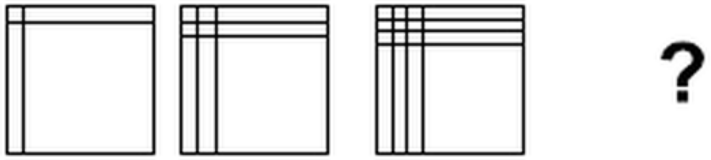
Step 2: Track distinctive features The first motif has its small square-like head at the upper left and its long horizontal foot along the bottom. After a clockwise quarter-turn, that head moves to the upper right and the long foot becomes the left vertical part. The central notches rotate with the outline and retain their order around the figure.

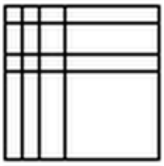
Step 3: Test the choices Option (A) has the required head at the upper right, the long member on the left, and the correctly turned central recess. Option (B) gives a different orientation of the head and foot. Option (C) leaves the square-like head on the left and places the broad member on the wrong side. Option (D) has a different turn of the internal notches, despite its similar square frame. A match must preserve the complete connected outline, not merely the position of one arm.

Step 4: Conclusion The complete motif after the required clockwise quarter-turn is shown in (A). Hence, the correct option is (A).

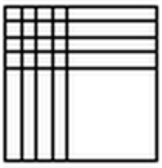
Quick Tip to Solve: Use the outer frame to measure the turn, then track a distinctive notch or short bar to reject reflected or slightly altered motifs.

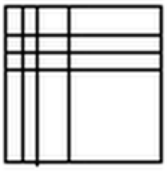
47. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]

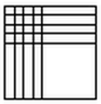


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A visual sequence can increase the number of repeated elements while keeping their spacing and orientation unchanged.
- Count interior lines separately from the fixed outer border: each new vertical line and each new horizontal line creates another small square in the upper-left lattice.

Step 1: Count the lines in the three terms In the first square there is one interior vertical line near the left side and one interior horizontal line near the top. In the second square there are two such interior vertical lines and two horizontal lines. In the third there are three of each. The outer four sides of the large square are unchanged in every term, so they must not be counted as additional inserted lines.

Step 2: Extend the two counts together The interior-line counts follow $(1,1),(2,2),(3,3)$, where the first entry counts verticals and the second counts horizontals. The next term must therefore have $(4,4)$. The four vertical lines must remain close to the left edge and the four horizontal lines close to the top edge, extending across the square just as the previous lines do. This produces an equally spaced upper-left grid, not a grid moved into another corner.

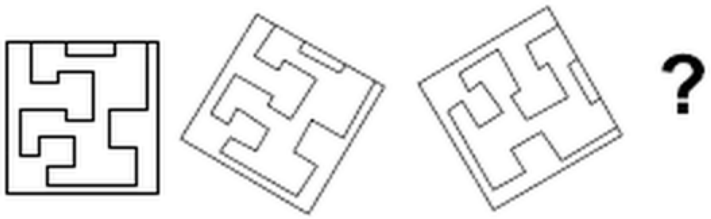
Step 3: Check every proposed grid Option (C) has four interior verticals and four interior horizontals in the required positions. Option (A) has only three interior lines in each direction and essentially repeats the previous stage with altered spacing. Option (B) has four vertical lines but only three horizontal lines, so it advances just one of the two counts. Option (D) moves the horizontal group downward, instead of adding the next line to the group near the top. Thus neither an incomplete count nor a displaced group continues the given simultaneous growth.

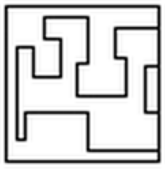
Step 4: Conclusion The fourth figure requires four interior vertical lines and four interior horizontal

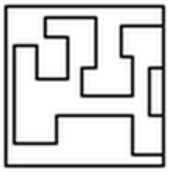
lines adjacent to the left and top edges, respectively. Hence, the correct option is (C).

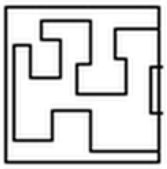
Quick Tip to Solve: For growing grids, write the ordered pair (interior verticals, interior horizontals) under each term; this prevents the fixed border from distorting the count.

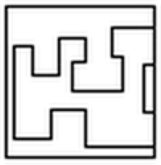
48. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]

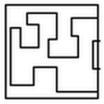


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A rotation changes orientation without changing the lengths, connections or order of the parts of a figure. Reflections reverse the handedness and are a different operation.
- The square frames successively turn clockwise through equal increments of 30°. Thus the fourth figure is the original motif rotated clockwise by 90°.

Step 1: Identify the repeated transformation Compare the outer square in the three problem figures. It starts upright, turns clockwise by approximately 30°, and then turns through another 30°. The internal motif follows the same rotation; its notches and connected branches do not exchange places independently. The continuation must therefore make one further equal clockwise turn. The total turn from the first position is $3 \times 30^\circ = 90^\circ$, so the final frame is upright again.

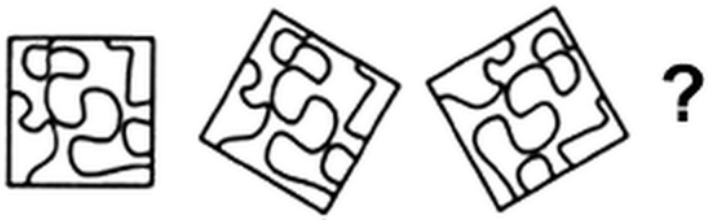
Step 2: Track distinctive features Follow the narrow short bar near the top of the first upright square. Under a clockwise quarter-turn it becomes a short vertical bar along the right side. At the same time, the bottom horizontal boundary of the larger connected motif turns into the left-hand vertical boundary, and the upper and lower recesses take the corresponding right-angle positions.

Step 3: Test the choices Option (C) has the short vertical right-hand bar at the required height and preserves the two upper recesses and the lower central indentation of the turned motif. Option (A) changes the arrangement of the left-hand indentation. Option (B) places the isolated right-hand bar too low. Option (D) changes the upper central indentation into a shorter, narrower feature. These are changes of the pattern, not consequences of rotating the whole figure.

Step 4: Conclusion The complete motif after the required clockwise quarter-turn is shown in (C). Hence, the correct option is (C).

Quick Tip to Solve: Use the outer frame to measure the turn, then track a distinctive notch or short bar to reject reflected or slightly altered motifs.

49. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- A figure sequence can change orientation while retaining exactly the same internal connections. Follow distinctive loops and their contacts with the square rather than the apparent tilt of the outside frame.
- A rotation preserves the handedness of an asymmetric pattern: the order of its curves around the boundary remains unchanged. A reflection would reverse that order and must be rejected.

Step 1: Identify the unchanged pattern The three problem figures contain the same continuous irregular network inside a square. In particular, identify the paired rounded lobes near one corner,

the central S-shaped bend, and the long return curve beside another side. Their sizes and mutual connections do not change. Thus the next figure must be a rotated copy of this network, rather than a new set of curves or a mirror image.

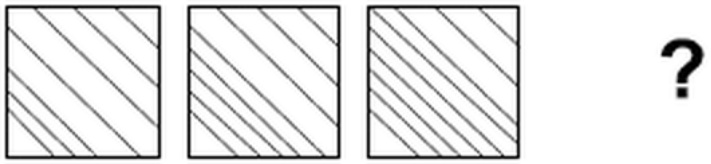
Step 2: Continue the turn The square and its contents turn together through successive equal angular changes. Continuing that motion brings the outside frame back to a horizontal and vertical alignment. Track the double rounded loop to the upper-right region, the central S-shaped connection through the middle, and the long curve down the left-hand side. These give much stronger checks than the square outline, which is identical in every answer.

Step 3: Compare the answer figures Option (C) retains the required connections at the lower boundary and the central bend while placing the paired loop in its continued position. Option (A) changes the lower return connection; option (B) changes the curve joining the central and lower portions; option (D) changes the lower-left junction. Each is close in outline, but fails the tracing test at an internal connection.

Step 4: Conclusion The continued rotation gives the network in option (C). Hence, the correct option is (C).

Quick Tip to Solve: For a rotating line network, follow one distinctive loop and then trace its neighbouring junctions; a matching outer square alone is insufficient.

50. Which one of the answer figure will complete the sequence of the three problem figures ? [4 marks]



(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- In a line sequence, compare both the direction of the lines and the positions of the narrow gaps. Parallel lines can form a moving band even though every frame has the same square boundary.
- The continuation must preserve the downward-right slope of the lines and advance the closely spaced portion by the same progression seen in the problem figures.

Step 1: Separate the fixed and changing features All three frames have the same square and the same family of parallel diagonal lines. None of the lines changes its slope, and there is no rotation of the complete square. The useful changing feature is the distribution of the narrow spaces between neighbouring diagonals. Therefore, count and locate the close pairs instead of selecting the answer with the most similar overall darkness.

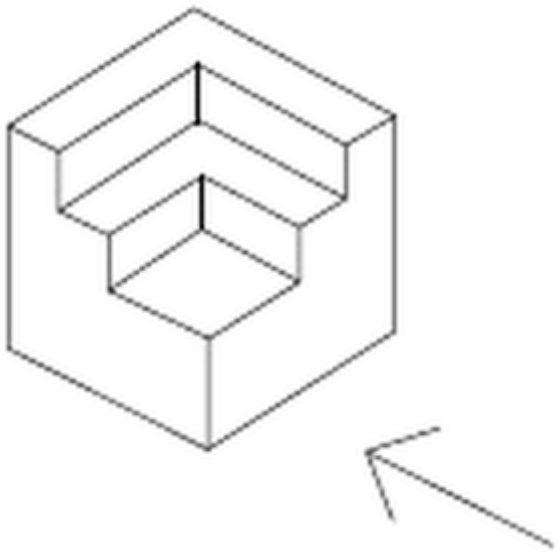
Step 2: Advance the closely spaced band Read the first, second and third squares in order. The extra close diagonals extend progressively from the lower-left part into the diagonal band passing across the square. At the next stage the established narrow intervals must continue their orderly progression, with the remaining wider spaces staying consistent with that advance. The lines must remain parallel throughout; a jump or reversal of the close spacing does not follow the sequence.

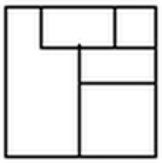
Step 3: Test all four continuations Option (D) continues the position and spacing of the diagonal band after the third frame. Option (A) shifts the close group too far into a different part of the square. Option (B) does not continue the required distribution of the narrow intervals. Option (C) changes the spacing near the opposite end instead of extending the established progression. Thus only (D) agrees with both the fixed slope and the changing spacing.

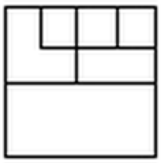
Step 4: Conclusion The fourth frame is the diagonal-line arrangement in option (D). Hence, the correct option is (D).

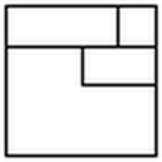
Quick Tip to Solve: Ignore the identical square outlines: compare the narrow gaps between successive parallel lines and follow their progression across the frame.

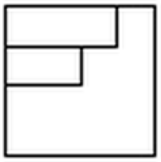
51. The 3 – D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

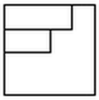


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An orthographic view is obtained by looking parallel to the indicated arrow. Depth in that direction disappears; widths and heights perpendicular to it remain visible.
- Only visible edges belong in the ordinary outline view. An edge hidden behind a nearer solid face is not drawn as a new solid line.

Step 1: Choose the viewing side The arrow points towards the object from the lower-right side of the perspective drawing. Look directly along that direction, rather than from above or from the opposite face. The outer high walls then project to a square boundary. The oblique edges in the perspective picture become horizontal or vertical lines in this view; their perspective slant must not be copied into the answer.

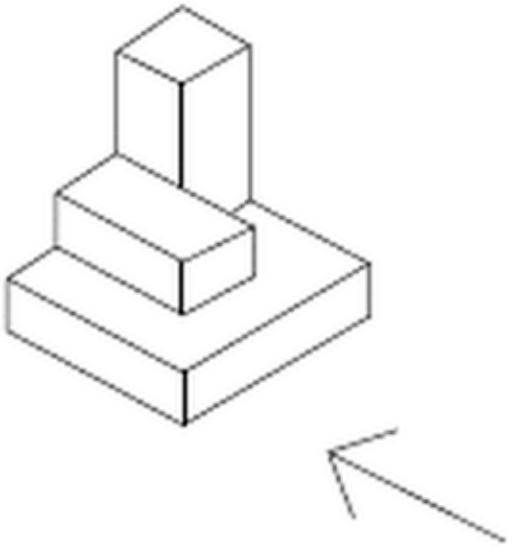
Step 2: Project the recessed steps The object has a stepped recess enclosed by taller walls. Follow the upper ledge and then the lower ledge, comparing their heights and how far each extends across the visible face. From the indicated side the upper horizontal edge runs from the left towards the right before meeting a short downward boundary. The lower step lies beneath its left portion, producing a descending staircase towards the left. The tall wall on the right remains uninterrupted.

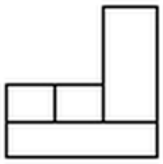
Step 3: Reject incompatible edge patterns Option (D) gives precisely this arrangement: a high horizontal ledge, a shorter lower ledge to its left, and a clear full-height right-hand region. Option (A) introduces a long internal vertical division through the lower area. Option (B) adds a full-width intermediate horizontal line and extra upper divisions. Option (C) puts the lower step on the opposite side. Those features would require different visible faces or a different viewing direction.

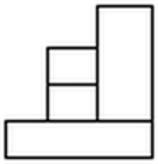
Step 4: Conclusion The projection along the arrow is option (D). Hence, the correct option is (D).

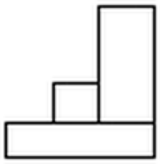
Quick Tip to Solve: Fix the arrow direction first, then trace the visible ledges from the highest to the lowest; reject any option that reverses their left-right order.

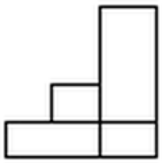
52. The 3 – D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

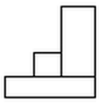


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- For an elevation along an arrow, collapse the dimension parallel to the line of sight. A ledge extending in that direction does not retain its perspective length in the final view.
- A projection shows changes in height and visible face boundaries, but it does not show every edge visible in the original three-dimensional picture.

Step 1: Read the three height levels The object consists of a broad low rectangular base, an intermediate raised block and a taller narrow upright behind it. The arrow views it from the lower-right direction of the drawing. Thus the desired answer is a side elevation with a continuous horizontal base and two successively taller portions above it. The top of the narrow upright must be the highest point of the outline.

Step 2: Collapse the depth correctly Look along the arrow and project all corners onto a plane

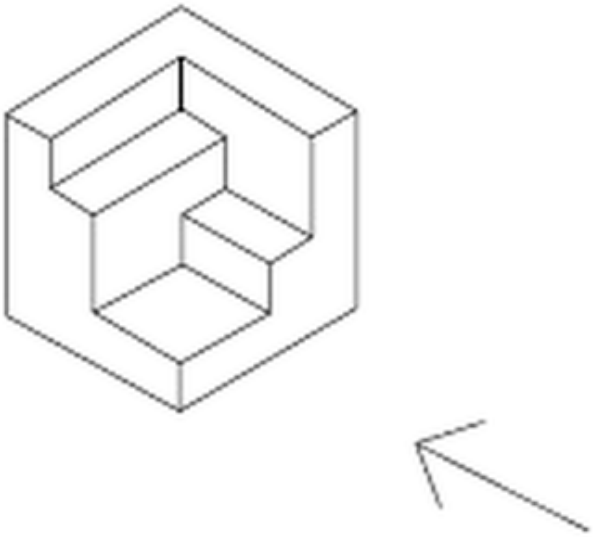
perpendicular to it. The intermediate block overlaps the tall upright in depth, leaving one lower rectangular step beside the upright. Its top is a single horizontal line. The upright projects as one tall rectangle whose lower edge ends at the top of the base, rather than continuing as an arbitrary seam through the base. The broad base remains one low rectangle beneath both raised parts.

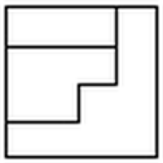
Step 3: Check the candidate elevations Option (C) has the continuous base, one intermediate-height step, and the tall upright in the correct order. Option (A) adds a vertical subdivision within the intermediate step. Option (B) divides that raised portion horizontally into two stacked parts, although no such visible boundary is required in this direction. Option (D) carries the upright division down through the base. These additional edges are not present in the required visible projection.

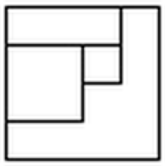
Step 4: Conclusion The correct elevation is the stepped profile in option (C). Hence, the correct option is (C).

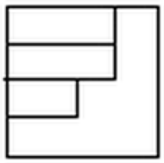
Quick Tip to Solve: In a stepped-solid projection, check the base as well as the silhouette: an unnecessary line through an otherwise continuous base often identifies a wrong option.

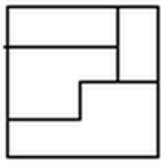
53. The 3 – D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

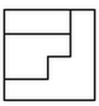


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- The view in a given direction preserves the heights of visible steps while suppressing the depth along the viewing ray. Perspective diagonals become horizontal or vertical projection edges.
- A recess is read by tracing its visible boundary. Lines hidden by the nearer raised face must not be added as solid internal divisions.

Step 1: Set up the arrow view The observer is on the lower-right side of the illustrated solid and looks towards the stepped opening. The high outside walls produce the square outer boundary. Identify the upper rim, the intermediate shelf on the left and the lower opening before deciding which internal lines survive the projection. Looking from the opposite side would interchange important left-right relationships.

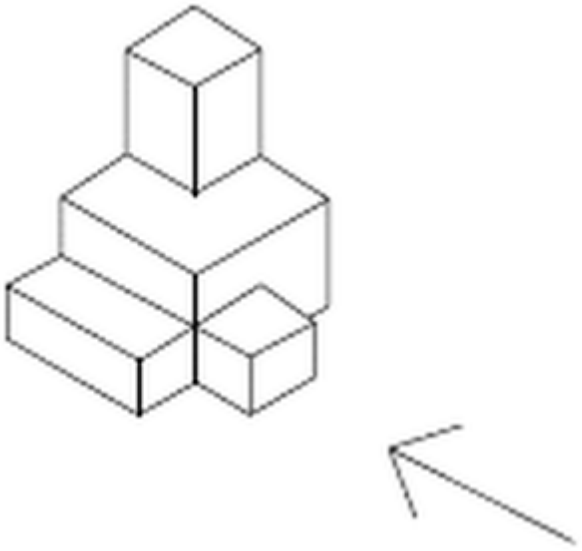
Step 2: Trace the visible staircase The upper visible shelf projects as a horizontal band extending across most of the upper width, ending at a vertical boundary near the right-hand side. Below it the recess outline moves downward in successive steps towards the left: first a short vertical drop, then a horizontal return, then another downward segment. This gives one continuous staircase-like boundary, with the broad right region remaining clear rather than divided by a full horizontal line.

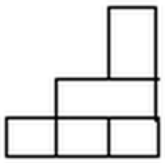
Step 3: Match the boundary and eliminate extras Option (A) has the required upper band and the continuous stepped recess boundary. Option (B) inserts a separate rectangular division just under the upper band. Option (C) extends intermediate horizontals too far and introduces an extra lower vertical segment. Option (D) carries a horizontal edge across the right-hand region. These lines change which surfaces would be visible, so they cannot be accepted merely because the outer square is correct.

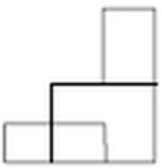
Step 4: Conclusion The visible stepped recess projects as shown in option (A). Hence, the correct option is (A).

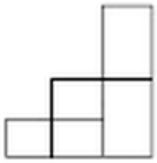
Quick Tip to Solve: Trace the recess boundary as one connected staircase; extra interior segments in the choices are as significant as an incorrect outer silhouette.

54. The 3 – D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

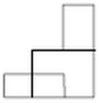


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Orthographic projection along an arrow removes depth and keeps the visible height profile. Different blocks can overlap in the view, so their perspective edges need not all remain visible.
- An internal solid line is justified only where a visible face changes plane or one visible surface ends. A hidden block boundary must not be continued through a nearer face.

Step 1: Establish the outline The arrow looks towards the solid from its lower-right side. The three main height levels are the low base, the wider intermediate raised portion, and the narrow top upright. Their projection gives a stepped outside profile rising towards the right. Several options share this outline, so the answer cannot be selected by the silhouette alone; the visible internal boundaries decide it.

Step 2: Locate the surviving lower edge The forward low blocks overlap part of the lower face in this

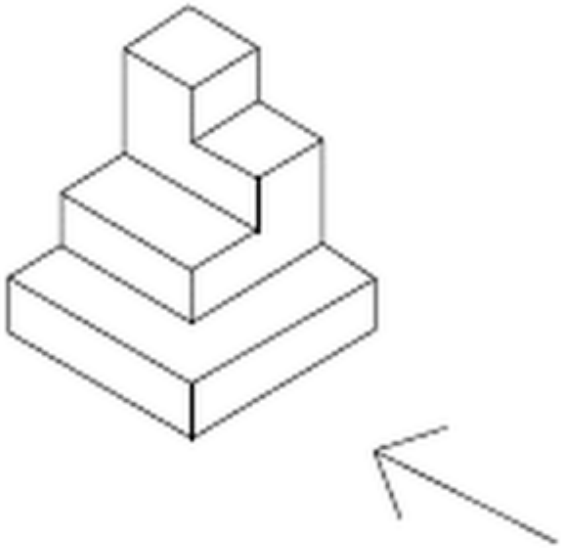
direction. Their top produces a short horizontal edge across the lower-left region and a vertical end near the middle. The broad right-hand face is uninterrupted below the intermediate top. The top upright begins at that intermediate level, with no reason to extend its side boundary down through the larger body. Thus the view contains a short lower-left division but no full-width bottom strip.

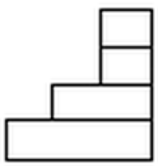
Step 3: Compare internal line arrangements Option (B) shows the short lower-left division and leaves the remaining body face clear, while preserving the correct stepped outline. Option (A) divides the whole base into a continuous strip and adds a central vertical seam. Option (C) adds vertical and horizontal divisions inside the right-hand region. Option (D) removes the horizontal boundary at the foot of the top upright, merging it into the middle face. Each of these loses or adds an edge relative to the indicated view.

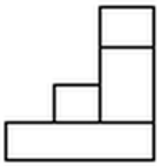
Step 4: Conclusion The required view, including its visible internal boundary, is option (B). Hence, the correct option is (B).

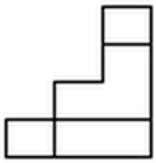
Quick Tip to Solve: When several options have the same stepped silhouette, inspect which lower edges are actually visible after the front blocks overlap the rear ones.

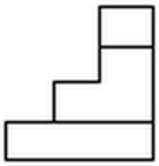
55. The 3 – D figure shows the view of an object. Identify the correct view in the direction of the arrow, from amongst the answer figures. [4 marks]

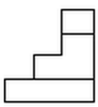


(A) 

(B) 

(C) 

(D) 

Correct Answer: (D) 

Solution:

Concept:

- An elevation is obtained by looking parallel to the indicated arrow. Depth collapses in this view, while horizontal positions and vertical levels remain.
- Only visible boundaries are drawn as solid lines. An edge behind a solid face must not be continued through that face.

Step 1: Fix the viewing face Look from the lower-right towards the object, along the arrow. The square plinth appears as a horizontal rectangular base. Above it the visible outline rises in steps towards the right, ending in the highest column. The isometric sloping edges represent depth directions; they do not remain sloping in the elevation.

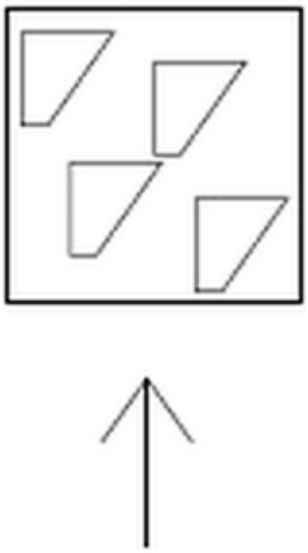
Step 2: Trace the visible changes of level Start at the left end of the base and follow the exposed upper boundary. There is a low step, then the intermediate ledge and finally the tall right-hand part. The uppermost short horizontal division is visible on the tall part. At the lower levels the faces overlap in depth, so the view does not acquire extra vertical subdivisions merely because several depth edges can be seen in the perspective drawing.

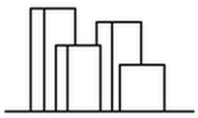
Step 3: Eliminate the extra internal edges Option (D) has the required rising outline and the visible horizontal boundaries. Option (A) continues an additional horizontal separation through the intermediate area. Option (B) inserts a vertical separation on the middle ledge, while option (C) also carries a vertical line down through the base. Those additional solid lines do not represent exposed edges when viewed along the arrow.

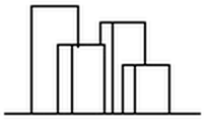
Step 4: Conclusion The visible stepped elevation is the fourth answer figure. Hence, the correct option is (D).

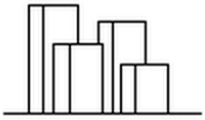
Quick Tip to Solve: Trace the outside silhouette first, then add only edges facing the observer; do not copy every isometric edge into the elevation.

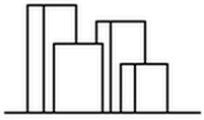
56. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

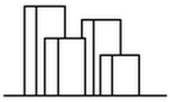


(A) 

(B) 

(C) 

(D) 

Correct Answer: (C) 

Solution:

Concept:

- Looking in the arrow direction gives a front elevation: left and right stay in their original order, while near objects can hide parts of farther objects.
- A sloping side in a polygonal plan determines the horizontal position of a visible vertical corner. Compare these corner positions, not just the outline heights.

Step 1: Read the near and far pairs The arrow points upwards. The lower pair is nearer the observer and the upper pair is farther away. In each pair, the objects occupy staggered horizontal intervals. The nearer left object overlaps the right-hand part of the far-left object; the nearer right object likewise covers part of the object behind it. Keep this front-to-back ordering throughout the comparison.

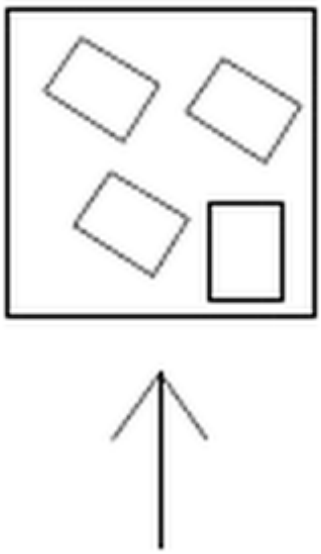
Step 2: Project the corners vertically The plan footprints have one vertical side and an oblique side. Their nearer corners are offset from the full projected width. Consequently, the exposed faces in the elevation contain vertical corner lines towards the left of their respective projected rectangles. Where a front object covers a rear one, the rear edge stops at the front outline rather than showing through it.

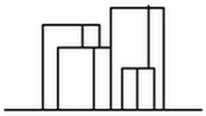
Step 3: Compare the four edge arrangements Option (C) keeps the corner lines and the overlaps in the required order for both pairs. Option (A) moves the foreground corner divisions to the wrong side. Option (B) loses the corresponding rear-left division, while option (D) gives the right foreground object the opposite division. These differences are visible-edge differences, even though the general stair-like silhouette is similar.

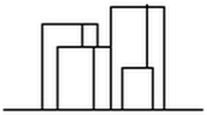
Step 4: Conclusion The third figure has the matching projected corner lines and occlusion. Hence, the correct option is (C).

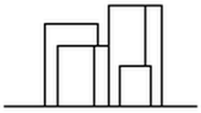
Quick Tip to Solve: Mark the lower pair as foreground before projecting: a rear vertical edge must stop wherever that foreground face covers it.

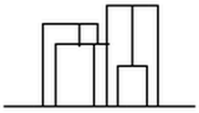
57. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

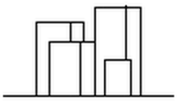


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- Orthographic elevation removes depth without reversing the left-to-right order shown in the plan.

- For an obliquely placed rectangular block, the projected vertical corner separates its two visible faces; a block aligned with the viewing direction has no such internal corner line.

Step 1: Identify the aligned foreground object The lower-right footprint is aligned with the page axes, whereas the other three rectangles are oblique. Along the upward arrow, that lower-right block is in front of the tall right-hand object. Its elevation is therefore a simple foreground rectangle, with no artificial vertical seam introduced in its middle.

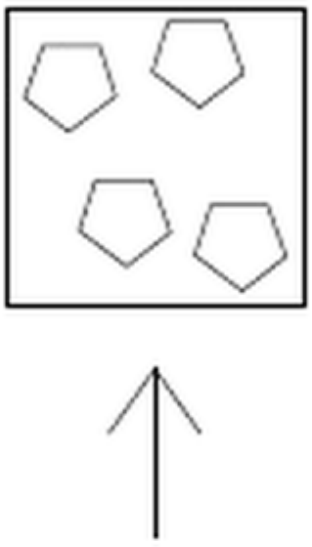
Step 2: Follow the exposed corner lines For each oblique footprint, project the front-facing corner onto the horizontal viewing line. The nearer lower-left block masks part of the upper-left block, and the lower-right block masks the bottom of the upper-right object. A rear corner line can be visible above a foreground object but must end where it meets the foreground outline. This termination is essential: a solid line cannot continue through an opaque block.

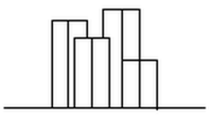
Step 3: Reject misplaced or extended divisions Option (B) retains the simple lower-right face and the appropriate corner divisions on the oblique objects. Option (A) adds a division inside the aligned lower-right face and mishandles the right-hand corner. Option (C) omits a visible left-hand rear division. Option (D) continues an unwanted vertical line through the overlap near the middle. Thus the common outer outline alone is not enough to choose the view.

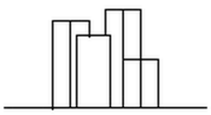
Step 4: Conclusion The second answer figure preserves the visible corners and hides the covered edges. Hence, the correct option is (B).

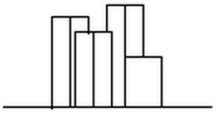
Quick Tip to Solve: Use the one axis-aligned footprint as a quick check: its foreground face should remain a plain rectangle in this viewing direction.

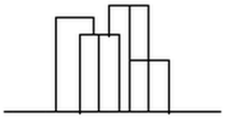
58. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

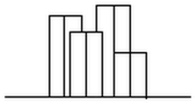


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- The upward arrow fixes the foreground at the bottom of the plan. Projected positions remain in left-to-right order.
- A polygonal footprint gives several vertical edges in elevation. Only edges on visible faces survive; a nearer block hides the lower portion of a rear edge.

Step 1: Order the four polygonal objects Read the two lower pentagons as the nearer objects and the two upper pentagons as the farther objects. The nearer left pentagon overlaps the projected interval of the upper-left pentagon. Similarly, the lower-right pentagon lies in front of part of the upper-right pentagon. The four objects must not be treated as one flat row.

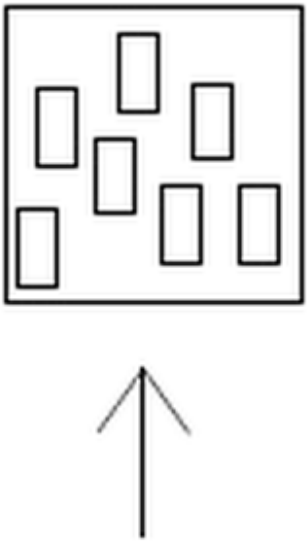
Step 2: Locate the polygon corners Each pentagonal footprint has a corner pointing towards the observer and oblique edges meeting that corner. Project these corner positions vertically. The front-facing corners create the internal divisions in the visible rectangular elevations. At overlaps, the foreground top boundary cuts off the rear vertical edge; it must not be replaced by a continuous line through the nearer face.

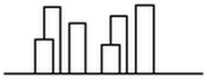
Step 3: Match both outline and divisions Option (A) gives the correct horizontal alignment of the exposed pentagonal corners and the foreground boundaries. Option (B) changes the left foreground overlap and its corner termination. Option (C) changes the division and level arrangement around the right foreground object. Option (D) removes required divisions on the rear objects and shifts the near-object boundaries. Inspecting these internal lines distinguishes figures whose broad outlines initially look alike.

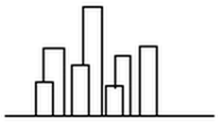
Step 4: Conclusion The first answer figure is the matching elevation. Hence, the correct option is (A).

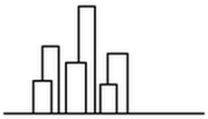
Quick Tip to Solve: For polygonal blocks, project the nearest vertex before checking the silhouette; its vertical edge often distinguishes otherwise similar options.

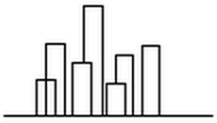
59. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

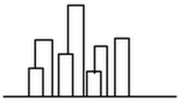


(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution:

Concept:

- An elevation in the indicated direction retains horizontal positions but removes depth. Nearer blocks hide the lower portions of farther blocks in overlapping horizontal intervals.
- Each separate rectangular footprint must be accounted for. Count visible blocks and match their horizontal grouping before using the relative heights drawn in the candidate figures.

Step 1: Count and group the footprints There are seven rectangular footprints. Looking upwards along the arrow, their horizontal projections form three overlapping pairs and one further isolated rectangle at the extreme right. The leftmost lower footprint overlaps the next footprint to its right; the same pattern repeats for the middle and the next pair. The seventh footprint occupies a separate interval at the right edge and cannot disappear behind another object in this viewing direction.

Step 2: Preserve the foreground overlaps Within each overlapping pair, the lower footprint in the plan lies nearer the viewer. Its rectangular face hides the lower part of its partner, so the rear vertical boundary ends at the foreground top. This gives three stepped paired groups. An opaque front face must remain unbroken by the covered edge of its rear partner. The isolated seventh object must still

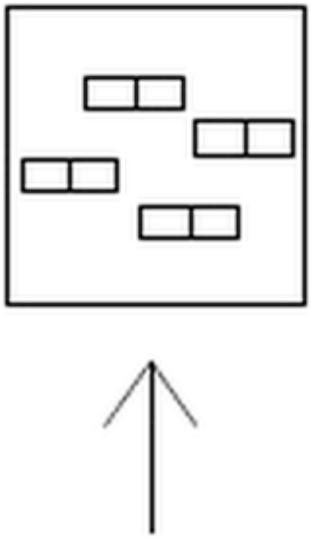
appear as its own rectangular elevation beyond those three groups.

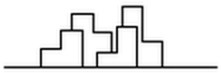
Step 3: Eliminate the incorrect arrangements Option (B) shows three overlapping pairs followed by a separate rectangle at the extreme right, accounting for all seven objects. Option (C) shows only the three pairs: its apparent last taller rectangle is the rear member of the third pair, not a separate seventh object. Option (A) likewise fails to retain the required seven-object grouping. Option (D) introduces vertical rear edges through foreground faces, violating the depth order. The decisive checks are the missing final object and the termination of the internal edges; no assumption that footprint depth determines height is needed.

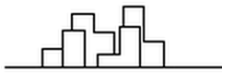
Step 4: Conclusion The second answer figure accounts for all seven blocks and their correct foreground occlusion. Hence, the correct option is (B).

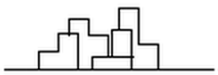
Quick Tip to Solve: Count three overlapping pairs plus the isolated rightmost block before comparing details; six visible rectangles cannot represent this seven-object plan.

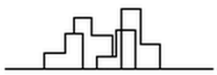
60. The problem figure shows the top view of objects. Looking in the direction of the arrow, identify the correct elevation, from amongst the answer figures. [4 marks]

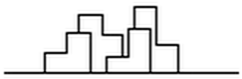


(A) 

(B) 

(C) 

(D) 

Correct Answer: (A) 

Solution:

Concept:

- The arrow fixes the direction of projection. Depth disappears in elevation, while the horizontal intervals occupied by the individual objects remain.
- A visible vertical corner ends when it is hidden by a nearer object. Hidden edges must not be extended through a foreground face.

Step 1: Read the staggered positions There are four paired rectangular footprints, placed at different depths. Looking upwards from the arrow, the lowest pair is nearest, the left-hand pair lies behind it, and the higher pairs are farther away. Their staggered horizontal positions produce overlapping projected faces, rather than four isolated rectangles. Begin with the low foreground interval, then work backwards.

Step 2: Track the exposed stepped boundary Project the ends and the internal join of each paired footprint onto the horizontal viewing line. This gives the positions where a vertical boundary can occur in the elevation. Keep the outlines of the nearer objects uninterrupted and stop the lines of the farther objects at those outlines. The upper silhouette is stepped, but the central lower boundary also matters because a nearer member masks part of the object behind it.

Step 3: Use the central overlap to decide Option (A) shows the front member covering the correct lower central interval, with the higher rear outlines visible around it. Option (B) leaves a separate low rectangle at the left and changes that overlap. Option (C) extends the low central face across an interval that should remain exposed. Option (D) carries a rear vertical division through the foreground face. Thus these alternatives cannot be chosen merely because they reproduce several of the same upper steps.

Step 4: Conclusion The first figure has the correct projection and visible-edge termination. Hence, the correct option is (A).

Quick Tip to Solve: Check the lowest foreground overlap after matching the top silhouette; an extra line through that face reveals an incorrect elevation.

61. The White House is which one of the following ? [4 marks]

(A) Residence of Prime Minister of Germany

(B) Residence of Prime Minister of France

(C) Residence of Prime Minister of Spain

(D) Residence of President of USA

Correct Answer: (D) Residence of President of USA

Solution:

Concept:

- A landmark can be identified by its location and its principal civic function. The White House is the official residence and workplace of the President of the United States.
- A head of state or government must be matched to the correct country. Similar official titles do not

make the residences interchangeable.

Step 1: Identify the building and its use The name White House refers to the presidential residence in Washington, D.C., in the United States of America. It is associated with the American presidency and contains the residential and working spaces used by the President. Thus the relevant relationship is White House, United States, President. The question asks for this institutional function rather than the colour or architectural style of the building.

Step 2: Compare every listed office Option (D) states that the White House is the residence of the President of USA, which matches the identification. Option (A) assigns it to Germany, option (B) to France and option (C) to Spain. Each of those options names a European country and a prime-ministerial office instead of the American presidential office. None describes the Washington landmark. The country and the office must both match, so the alternatives cannot be accepted merely because they also describe official residences.

Step 3: Conclusion The White House is the residence of the President of the United States of America. Hence, the correct option is (D).

Quick Tip to Solve: Associate the White House with Washington, D.C. and the US presidency; check both the country and the office in each option.

62. In the Northern Hemisphere the summer sun rises from which one of the following directions ?

[4 marks]

(A) North East

(B) North West

(C) South East

(D) South West

Correct Answer: (A) North East

Solution:

Concept:

- Earth's axial tilt makes the apparent sunrise position move north and south of due east over the year. Due-east sunrise is the equinox reference.
- During Northern Hemisphere summer the Sun has a northerly declination. At ordinary inhabited northern latitudes where sunrise occurs, its rising point is north of east.

Step 1: Locate the summer sunrise quadrant Begin with the eastern horizon because sunrise occurs on that side of the sky. In Northern Hemisphere summer, the apparent daily path of the Sun is displaced towards the north compared with its equinox path. Consequently its rising position lies between north and east, in the north-east quadrant. This is the seasonal orientation used in elementary solar-path and building-orientation questions; the exact azimuth depends on latitude and date.

Step 2: Eliminate the other directions North East, option (A), gives the correct eastern quadrant with the required northward seasonal displacement. North West and South West, options (B) and (D), lie on the western side and therefore do not describe the usual sunrise direction. South East, option

(C), is an eastern direction but has the opposite seasonal displacement: it corresponds to the winter sunrise side in the Northern Hemisphere. At sufficiently high polar latitudes there may be no daily sunrise during part of summer; the question uses the normal seasonal sunrise convention.

Step 3: Conclusion In the Northern Hemisphere, the summer sunrise is towards the North East. Hence, the correct option is (A).

Quick Tip to Solve: Start at due east for an equinox sunrise, then shift north for northern summer and south for northern winter.

63. In which of the following States is the Golden Temple located ? [4 marks]

(A) Haryana

(B) Punjab

(C) Assam

(D) Nagaland

Correct Answer: (B) Punjab

Solution:

Concept:

- A monument-location question requires the city and its containing state to be distinguished. The Golden Temple, also called Harmandir Sahib, is in Amritsar.
- Amritsar is a city in Punjab. Therefore the state associated with this landmark is Punjab, not a neighbouring state or another region of India.

Step 1: Identify the landmark and city The Golden Temple is the renowned Sikh shrine at Amritsar. Its name is associated with the gilded exterior of the principal shrine, which stands within the sacred pool of the complex. Identifying the monument as Harmandir Sahib leads directly to Amritsar. Since the question asks for a state rather than a city, Amritsar is an intermediate identification, not the final response.

Step 2: Match the city to the listed state Amritsar belongs to Punjab, so option (B) gives the required state. Haryana, option (A), is another northern Indian state, but it does not contain Amritsar. Assam and Nagaland, options (C) and (D), are in north-eastern India and are not the location of this shrine. Proximity, a familiar state name, or a different famous religious site cannot replace the specific city-state relationship asked here. The chain Golden Temple, Amritsar, Punjab uniquely selects the answer.

Step 3: Conclusion The Golden Temple is located in Amritsar, Punjab. Hence, the correct option is (B).

Quick Tip to Solve: For monument questions, recall a three-part chain: monument, city, state. Here it is Golden Temple, Amritsar, Punjab.

64. What is the thickness of a one and a half brick thick wall ? [4 marks]

(A) 9″

(B) 12″

(C) 18″

(D) 13.5″

Correct Answer: (D) 13.5″

Solution:

Concept:

- Brick-thickness terminology expresses wall thickness as a multiple of the nominal length of a brick. In the conventional imperial system used by these options, one brick thickness is 9 inches.
- A half-brick wall is nominally 4.5 inches thick, and a one-and-a-half-brick wall combines one brick thickness with another half brick thickness.

Step 1: Interpret the masonry terminology The phrase one and a half brick thick describes the wall dimension across its thickness, not its height, and not one and a half courses of masonry. The conventional nominal thicknesses in this imperial series are 4.5 inches for half a brick and 9 inches for one brick. The options are all given in inches, so the calculation must retain that system instead of mixing it with a metric modular-brick size.

Step 2: Calculate and compare the thickness Take one and a half times the nominal one-brick thickness:

$$t = 1.5 \times 9\,\text{in} = 13.5\,\text{in}.$$

Equivalently, adding one brick and half a brick gives $9 + 4.5 = 13.5$ inches. Option (A), 9 inches, describes a one-brick wall rather than a one-and-a-half-brick wall. Option (C), 18 inches, is twice 9 inches and corresponds to two brick thicknesses. Option (B), 12 inches, is not the result of the stated nominal brick multiple. Option (D) alone matches the calculated thickness. These are nominal wall dimensions rather than a demand to add separate mortar joints to the given convention.

Step 3: Conclusion A one-and-a-half-brick wall is nominally 13.5 inches thick. Hence, the correct option is (D).

Quick Tip to Solve: Remember the nominal imperial series: half brick 4.5 inches, one brick 9 inches, and one-and-a-half brick 13.5 inches.

65. Which one amongst the following supports the masonry above doors and windows ? [4 marks]

(A) Foundation

(B) Lintel

(C) Slab

(D) Wooden frame

Correct Answer: (B) Lintel

Solution:

Concept:

- An opening interrupts the continuous masonry load path. The masonry above it needs a spanning member to carry its weight to the supports on either side.
- A lintel is a horizontal structural member above a door or window opening. It transfers the load of the masonry above to the adjacent jambs or wall portions.

Step 1: Trace the load around the opening Over a door or window there is no continuous wall directly beneath the masonry because the opening must remain clear. The structural member immediately above that opening spans between its sides. It carries the masonry load over the gap and delivers reactions to the surrounding wall. This specific role identifies a lintel. Its material can vary, but its defining feature is its position and load-carrying function over an opening.

Step 2: Distinguish the listed components Option (B), Lintel, names the required spanning member. A foundation, option (A), supports the building at its base and transmits loads to the ground; it is not the member directly over a window or door. A slab, option (C), is generally the broad plate forming a floor or roof, rather than the specific opening-spanning component requested. A wooden frame, option (D), primarily locates and holds the door or window assembly. A normal frame is not substituted for the structural lintel supporting the masonry above. The decisive distinction is the direct load path across the opening.

Step 3: Conclusion The lintel supports the masonry above doors and windows. Hence, the correct option is (B).

Quick Tip to Solve: Follow the load: masonry over an opening transfers through the lintel to the wall on each side, then down to the foundation.

66. The Leaning Tower in Italy is located in which one of the following cities ? [4 marks]

(A) Florence

(B) Venice

(C) Pisa

(D) Rome

Correct Answer: (C) Pisa

Solution:

Concept:

- A landmark is identified by its conventional proper name and city. The famous Leaning Tower of Italy is the Leaning Tower of Pisa.
- Pisa is distinct from Florence, Venice and Rome. All four are Italian cities, so the country alone cannot distinguish the options.

Step 1: Identify the specific tower The internationally recognised Leaning Tower is the freestanding bell tower associated with the cathedral complex at Pisa. The name Leaning Tower of Pisa directly supplies the city requested. Its inclination is the feature that makes the landmark distinctive, but the question is geographical rather than a request to explain the structural cause of its lean. The answer therefore needs the city name.

Step 2: Check all four Italian cities Option (C), Pisa, is the exact city in the landmark's established name. Florence, option (A), is another major Tuscan city, so sharing the same broad region does not make it the location of the tower. Venice, option (B), and Rome, option (D), also contain celebrated Italian buildings, but neither is the location of the Leaning Tower of Pisa. These alternatives illustrate why remembering only that the monument is in Italy is insufficient. Matching the full landmark name to its city gives a unique selection without confusing it with a cathedral or tower in another Italian city.

Step 3: Conclusion The Leaning Tower is located in Pisa, Italy. Hence, the correct option is (C).

Quick Tip to Solve: Retain the city in the landmark name: Leaning Tower of Pisa. This prevents confusion with other famous Italian cities.

67. Which one of the garden of the following is a terraced garden in Srinagar ? [4 marks]

(A) Nishat

(B) Vrindaban

(C) Buddha

(D) Nehru

Correct Answer: (A) Nishat

Solution:

Concept:

- A terraced garden is arranged on successive levels, often following a natural slope; steps and water channels connect its different terraces.
- Nishat Bagh is a Mughal terraced garden in Srinagar, beside Dal Lake. The location and the terraced layout must both agree with the question.

Step 1: Identify the two identifying clues The question asks for a garden in Srinagar and specifies a terraced arrangement. A terraced garden is not simply a garden with flower beds: its ground is organised as a sequence of raised or stepped platforms. Nishat Bagh matches this description. Its layout uses the slope to create successive terraces, with the principal garden features arranged along the descending levels.

Step 2: Compare the named gardens Nishat is the Srinagar garden in the list. Vrindaban, commonly written Brindavan in the name of the famous gardens near Mysuru, is associated with Karnataka rather than Srinagar. Buddha and Nehru are names used for gardens and parks in several places, but neither is the named Mughal terraced garden identified by these clues. Selecting a generally familiar park name would ignore the specific Srinagar setting.

Step 3: Conclusion Nishat is the terraced garden in Srinagar. Hence, the correct option is (A).

Quick Tip to Solve: Link Nishat Bagh with Srinagar and Dal Lake; the stepped Mughal layout supplies the terraced-garden clue.

68. What amongst the following is the name of the famous museum in Hyderabad ? [4 marks]

(A) Falaknuma

(B) Salarjung

(C) Gandhi

(D) Nizam

Correct Answer: (B) Salarjung

Solution:

Concept:

- Architectural general awareness includes recognising important museums and distinguishing them from palaces and other landmarks in the same city.
- The Salar Jung Museum in Hyderabad is renowned for its collection of art objects and antiquities.

In the options its name is written Salarjung.

Step 1: Match the institution with the city The city in the question is Hyderabad, and the requested institution is a famous museum. The Salar Jung Museum is the well-known museum associated with Hyderabad. Its collections include objects from different regions and artistic traditions, so the name is identified through the institution itself rather than merely through a local building or a person connected with the city.

Step 2: Eliminate the other names Falaknuma refers to a celebrated palace in Hyderabad, so its association with the correct city does not make it the requested museum. Gandhi is not the name of the museum intended here. Nizam is strongly associated with Hyderabad and a separate Nizam museum also exists, but the conventional landmark identified by this general-awareness question is the Salar Jung Museum. Therefore choose Salarjung, the explicit museum name offered in option (B).

Step 3: Conclusion The intended famous museum is the Salar Jung Museum, written Salarjung in the options. Hence, the correct option is (B).

Quick Tip to Solve: Separate the type of landmark from its city: Hyderabad has famous palaces as well as museums; Salar Jung identifies the museum here.

69. Which one of the color is made when blue and yellow are mixed ? [4 marks]

(A) Violet

(B) Orange

(C) Green

(D) White

Correct Answer: (C) Green

Solution:

Concept:

- In the conventional artist's colour wheel, blue and yellow are primary colours, and mixing two primary pigments produces a secondary colour.
- For the paint or pigment mixing intended in this colour-awareness question, blue mixed with yellow gives green. Mixing coloured light follows a different model.

Step 1: Apply the pigment colour wheel Interpret the question using the usual drawing and painting convention. Blue and yellow are two of the primary pigment colours on the traditional colour wheel. Their mixture produces the secondary colour green. The exact shade can change with the particular pigments and their proportions: more yellow gives a yellower green and more blue gives a bluer green, but the basic colour family remains green.

Step 2: Check every alternative Violet is the conventional secondary colour obtained by mixing blue with red, so it does not match the given pair. Orange comes from red and yellow, which again uses a different pair. Green comes from blue and yellow and therefore fits. White is not obtained by mixing these two paints; white refers to a separate pigment in painting and should not be confused with the combination of suitable coloured lights. The question concerns the standard paint-mixing relation.

Step 3: Conclusion Mixing blue and yellow gives green in the conventional pigment-mixing model. Hence, the correct option is (C).

Quick Tip to Solve: Remember the three paint pairs together: blue + yellow gives green, red + yellow gives orange, and red + blue gives violet.

70. Which one of the following color suggests love and romance ? [4 marks]

(A) Blue

(B) Green

(C) Pink

(D) Brown

Correct Answer: (C) Pink

Solution:

Concept:

- Colour symbolism associates colours with moods or ideas in visual communication; these are design conventions rather than universal physical laws.
- Pink commonly suggests tenderness, affection, love and romance, making it the best match among the colours listed.

Step 1: Identify the emotional quality The words love and romance ask for an emotional association of colour, not a colour mixture or a material property. Pink is widely used to convey affection, gentleness and romantic feeling. Its relatively soft visual character suits such an association. The task is to select the strongest conventional match among the stated choices, while recognising that the meaning of a colour can vary with context and culture.

Step 2: Compare the remaining colours Blue more commonly suggests calmness, coolness or trust in basic design vocabulary. Green is linked with nature, freshness and growth. Brown often conveys earthiness, wood or a grounded and rustic feeling. Those associations do not answer the emotional clue as directly as pink. Although a designer could use any colour in a romantic composition, that possibility does not change the conventional association tested by this multiple-choice item.

Step 3: Conclusion Pink most directly suggests love and romance among the listed colours. Hence, the correct option is (C).

Quick Tip to Solve: In basic colour-symbolism questions, match the dominant association: pink with affection, green with nature and blue with calmness.

71. Which one of the following suggests the texture of the skin of the elderly persons ? [4 marks]

(A) Glossy

(B) Wrinkled

(C) Smooth

(D) Soft

Correct Answer: (B) Wrinkled

Solution:

Concept:

- Texture describes the perceived surface character of an object, such as smooth, rough, folded or wrinkled; it can be perceived visually as well as by touch.
- Wrinkles are folds and creases in a surface. They are a characteristic visual texture used when representing the skin of an elderly person.

Step 1: Recognise the visible surface feature The question asks for the texture suggested by elderly skin. A common visible feature is a network of folds and creases, described as wrinkles. In drawing or visual perception, these lines break up a uniform surface and indicate its changing relief. Thus wrinkled is the descriptive word that directly represents the characteristic surface feature being tested, without requiring every elderly person to have identical skin.

Step 2: Distinguish texture from other qualities Glossy describes a shiny surface that reflects light strongly, not the characteristic folds in elderly skin. Smooth means a relatively even surface without prominent creases, so it does not fit this clue. Soft describes how a material yields to touch and could coexist with many different visible textures; it is not the specific visible feature requested. Wrinkled directly names the folds and creases, making option (B) the best match.

Step 3: Conclusion Wrinkled describes the characteristic texture intended for the skin of elderly persons. Hence, the correct option is (B).

Quick Tip to Solve: For visual-texture questions, choose the word naming the visible surface pattern; wrinkles are creases, whereas softness is a touch property.

72. Which one of the following is fixed to drain water from a sloping roof ? [4 marks]

(A) Ridge

(B) Eave

(C) J. Bolt

(D) Gutter

Correct Answer: (D) Gutter

Solution:

Concept:

- A sloping roof directs rainwater down its pitched surface towards the lower edge, where the runoff must be collected and conveyed away.

- A gutter is a channel fixed along a roof edge to collect this water and discharge it towards a downpipe. A ridge, eave and J-bolt have different roles.

Step 1: Follow the rainwater path Rain falling on a pitched or sloping roof runs downhill under gravity. At the lower roof edge it should be gathered rather than allowed to fall randomly down walls or around the building. A gutter provides the collecting channel at this edge. It normally has a slight fall along its length so that the collected runoff moves towards an outlet and then into a downpipe or the connected drainage system.

Step 2: Check the function of each alternative The ridge is the upper line where two roof slopes meet, so it is not a channel fixed at the lower edge to collect runoff. The eave is the lower projecting edge of the roof; water reaches it, but the eave itself is not the collecting drainage fitting. A J-bolt is a hook-shaped fastener used in fixing components such as roof sheets, not a water channel. A gutter is specifically designed to collect and drain the water, which is the function asked for.

Step 3: Conclusion A gutter is fixed to collect and drain water from a sloping roof. Hence, the correct option is (D).

Quick Tip to Solve: Follow the runoff from roof slope to gutter to downpipe; a ridge is at the top, while the eave is the projecting lower edge.

73. Which one of the following is ideal flooring for a cinema hall ? [4 marks]

(A) Granite

(B) Brick

(C) Marble

(D) Carpet

Correct Answer: (D) Carpet

Solution:

Concept:

- A cinema interior must support clear reproduced speech and music. Surface finishes influence how much sound is reflected back into the auditorium.
- A soft, porous floor covering absorbs more incident sound than a smooth, hard stone floor and reduces the noise made by people moving along the aisles.

Step 1: Identify the performance required The key requirement here is the acoustic suitability of the auditorium, rather than a decorative stone appearance. Repeated reflections from large hard surfaces can prolong reverberation and reduce the clarity of dialogue. A suitable flooring finish should also soften footsteps, since the audience may move while a film is playing. These requirements favour a soft floor covering.

Step 2: Compare every listed material Granite in option (A) is hard and dense; its polished surface reflects sound and transmits noticeable footfall noise. Brick in option (B) is a hard masonry finish and does not provide the soft acoustic treatment wanted inside the seating area. Marble in option (C) is another hard stone with a reflective surface. Carpet in option (D), with its fibrous pile and often an

underlay, absorbs some sound and cushions footsteps. It therefore best satisfies the purpose among these choices.

Step 3: Conclusion Carpet is the ideal flooring among the listed materials for a cinema hall because it assists acoustic control and reduces footstep noise. Hence, the correct option is (D).

Quick Tip to Solve: For an auditorium-flooring question, compare sound absorption and footfall noise before choosing a material merely for its polished appearance.

74. Who among the following is the architect of the Punjab Haryana High Court Building ? [4 marks]

(A) Maxwell Fry

(B) Le Corbusier

(C) Louis Kahn

(D) Geoffrey Bawa

Correct Answer: (B) Le Corbusier

Solution:

Concept:

- The Punjab and Haryana High Court is a principal building of the Capitol Complex in Chandigarh. Questions about this complex test the association between a named building and its architect.
- Le Corbusier designed the principal monumental buildings of the Capitol Complex, including the High Court, the Assembly and the Secretariat.

Step 1: Recognise the named building The question identifies the Punjab Haryana High Court Building, the High Court in Chandigarh. Its strongly modelled concrete form, prominent roof and deep sun-protection elements belong to the monumental architecture of the Capitol Complex. This locates the question within Le Corbusier's Chandigarh work, rather than simply asking who participated in the development of the city.

Step 2: Distinguish the four architects Le Corbusier in option (B) is the architect associated with the High Court building. Maxwell Fry in option (A) also worked on Chandigarh, especially its residential and related civic architecture, but that involvement does not make him the designer of this High Court. Louis Kahn in option (C) is associated with major institutional projects such as the Indian Institute of Management at Ahmedabad. Geoffrey Bawa in option (D) is associated with Sri Lankan architecture and tropical modernism. Neither Kahn nor Bawa designed the named Chandigarh High Court.

Step 3: Conclusion The Punjab and Haryana High Court Building was designed by Le Corbusier. Hence, the correct option is (B).

Quick Tip to Solve: Associate Chandigarh's Capitol Complex monuments with Le Corbusier; distinguish the designer of a specific building from other architects who worked in the city.

75. Which one among the following is used for water conservation ? [4 marks]

(A) Water drainage

(B) Water evaporation

(C) Water harvesting

(D) Water flowing

Correct Answer: (C) Water harvesting

Solution:

Concept:

- Water conservation means reducing waste and retaining useful water for present or later use. A method that collects otherwise lost water directly serves this purpose.
- Water harvesting collects rainwater or runoff and stores it, or directs it towards groundwater recharge. It makes more of the available water useful.

Step 1: Identify the conservation process Read the alternatives for a process that deliberately captures a usable water resource. Water harvesting collects precipitation or runoff from suitable catchments, such as a roof, and conveys it through a collection arrangement. The collected water may be stored for appropriate use or sent to a recharge structure. In either case it reduces the loss of water that would otherwise leave the site as uncontrolled runoff.

Step 2: Eliminate the other processes Water drainage in option (A) primarily removes water from a place; drainage may be essential for a building, but removal alone is not water conservation. Water evaporation in option (B) changes liquid water into vapour and normally reduces the water immediately available in a storage tank or pond. Water flowing in option (D) describes motion, without any collection, storage or saving mechanism. Water harvesting in option (C) explicitly provides that mechanism and is therefore the conservation measure requested.

Step 3: Conclusion Water harvesting is used for water conservation by collecting water for storage or groundwater recharge. Hence, the correct option is (C).

Quick Tip to Solve: Look for an active saving mechanism: collecting, storing or recharging water indicates conservation; movement or evaporation by itself does not.

Drawing Test (100 marks)

76. In the space provided for the answer of this question, draw an aesthetic composition appropriate to this space using triangles and rectangles. There is no restriction to numbers, sizes, placement and directions of these shapes. Color this composition so that it becomes visually exciting. [50 marks]

Solution:

Concept:

- An aesthetic composition organises shapes through balance, hierarchy, rhythm and contrast. Triangles can suggest direction and movement, while rectangles can provide stable masses.
- A limited, coordinated colour palette can create a visually exciting result without sacrificing unity.

Differences in size, orientation and value should support the main focal area.

Step 1: Plan the composition within the answer space Lightly mark the limits of the available space and leave a narrow, consistent breathing margin. Place the main cluster slightly away from the exact centre to avoid a static, divided layout. Use one large oblique rectangle as a dominant mass and arrange two or three triangles around it so that their points direct attention towards the cluster. Include smaller rectangles to carry the visual movement towards another part of the space. Vary sizes freely, as the prompt permits, but retain a clear distinction between dominant and subordinate shapes.

Step 2: Develop balance and visual rhythm Arrange the principal shapes along a diagonal or gently changing directional path. Repeat triangles and rectangles at different scales rather than making every shape identical. Balance a large group on one side with a smaller, more intense group on the other. Allow some shapes to overlap, using clean shared boundaries and carefully resolved intersections. Keep several quiet negative spaces between groups so the composition remains readable. Check the whole arrangement from a distance: the eye should move through the design and return to its focal area rather than stop at an isolated corner.

Step 3: Use colour to strengthen the hierarchy Choose a small palette, for example warm orange and red balanced by cool blue, with a pale neutral background. Reserve the strongest complementary colour contrast for the focal cluster. Repeat one accent colour in smaller quantities elsewhere to unify the composition. Use lighter and darker versions of a colour to separate overlapping shapes, while keeping every fill flat and deliberate. Avoid adding unrelated pictorial objects: triangles and rectangles should remain the visible vocabulary. Keep edges crisp, colour evenly and check that the background does not overpower the geometric arrangement.

Step 4: Finish and assess the result Remove construction lines and repair uneven borders or accidental gaps. Confirm that the composition fits the actual answer space, has no unintended tangencies, and contains both triangular and rectangular forms. Review its balance in terms of visual weight rather than an equal count of shapes. The final design should have a dominant focal area, repeated supporting motifs and enough contrast to feel lively while still forming one coherent composition.

Step 5: Conclusion A suitable response is a balanced abstract composition of varied triangles and rectangles, organised around a clear focal area and unified by a limited but contrasting colour scheme. The composition plan uses scale, direction, overlap and negative space to make the coloured design visually exciting.

Quick Tip to Solve: Make a small thumbnail first: test the major dark and light masses before committing to detailed edges and colour in the full answer space.

77(a). Draw from imagination a gardener working in the garden. [50 marks]

Solution:

Concept:

- A convincing activity scene combines a clear main action, believable human proportions and a setting that identifies the task. The gardener should dominate the composition rather than disappear among decorative plants.

- Depth comes from overlap, diminishing scale, a consistent eye level and a shared light direction. Use a few tonal groups to separate foreground, middle ground and background.

Step 1: Choose the activity and arrange the scene Plan a landscape-format garden view with a gardener kneeling beside a flower bed and planting a young sapling. Place the gardener slightly to one side of the centre, leaving space in front of the hands for the action. Use a curved path to lead the eye from the foreground toward the planting area. Place a watering can and small hand trowel close to the gardener; keep them subordinate to the figure. Suggest a low hedge and a few trees behind the bed so that the scene unmistakably reads as a garden.

Step 2: Construct the figure and perspective Mark a single eye level before drawing the path and any low edging. Begin the gardener with a simple head oval, rib-cage mass, pelvis and jointed limb lines. Bend the torso toward the plant, support the body on one knee and place the other foot firmly on the ground. Show one hand supporting the root ball and the other pressing soil beside it. Check that the forearms meet the hands naturally and that the shoulders, hips and knees explain the pose. Draw larger leaves and soil clods near the viewer and smaller foliage farther away. Use overlaps to place the gardener in front of the background hedge.

Step 3: Develop detail, light and final emphasis Choose light from the upper left and keep it consistent on the face, clothing folds, pot, watering can and plants. Darken the contact shadows beneath the knee, foot and tools so the objects do not float. Model the figure with broad light, middle and dark values before adding small folds or leaf veins. Give the planting area the strongest useful contrast; make distant trees lighter and less detailed. Vary foliage shapes instead of repeating identical symbols. If using colour, group greens into a restrained range and introduce a warm shirt or flowers as a focal accent. Finish by checking the hand-to-plant contact, the grounded pose and the clear foreground-to-background progression.

Step 4: Conclusion A suitable composition shows a kneeling gardener planting a sapling beside a flower bed, with nearby tools, a receding path and quieter background greenery. The visible action, sound anatomy, consistent depth and unified lighting make the scene complete.

Quick Tip to Solve: Establish the gardener and the hand action first. Add plants around that focal group, then use contact shadows to connect the figure and tools to the ground.

OR

77(b). Draw from imagination a scene of a place for praying. [50 marks]

Solution:

Concept:

- A prayer scene should communicate quiet concentration through a clear focal area, restrained movement and an organised composition. Architecture establishes the setting while posture identifies the activity.
- A single eye level and coherent perspective make an interior believable. Controlled contrast and a consistent light source can suggest a peaceful atmosphere without filling every area with detail.

Step 1: Select a setting and organise the view Choose a quiet prayer hall viewed from an entrance, with a modest focal alcove on the far wall and a few people seated or kneeling in prayer. Keep the central route visually open so the eye travels into the room. Place the main praying figure in the middle ground, slightly off centre, and use a second smaller figure farther back to reinforce depth. Include only setting details that support the subject, such as a simple mat, a low platform and an opening admitting daylight. The design may be a respectful imagined prayer space; it need not copy a named monument or depend on elaborate religious ornament.

Step 2: Build the space and the praying figures Draw the eye-level line and use one vanishing point for the hall floor, wall junctions and parallel mat edges. Keep vertical wall edges upright. Establish the large proportions of the room before adding alcoves, columns or doors. Construct each person with simple masses, checking the relation of head, torso, arms and folded legs. Show lowered heads and still, compact poses; hands may be joined or resting naturally according to the chosen activity. Place the bodies securely on the mats with clear contact and overlap. Make distant figures and architectural details smaller, maintaining the same perspective system throughout.

Step 3: Create the mood with tone and finishing Let soft daylight enter from one side. Use a light patch on the floor or far wall to lead toward the focal praying group, and place the strongest contrast near that group rather than at the entrance. Keep shadows on figures, platform and architecture consistent with this light. Simplify repeated floor patterns so they recede in size and do not compete with the figures. Use subdued warm and cool tones if colour is employed, preserving a small range of harmonious hues. Finish with selective detail on the principal figure and focal alcove, leaving distant areas softer. Check that the prayer activity remains readable even when viewing the composition as a small thumbnail.

Step 4: Conclusion A suitable scene presents a peaceful prayer hall with a clearly posed praying group, receding floor and architecture, and soft directional light. The composition communicates prayer through human activity and atmosphere as well as the setting.

Quick Tip to Solve: Draw the main praying posture before ornament. If the activity is clear in silhouette and the floor lines converge consistently, a few quiet details can complete the setting.

OR

77(c). Draw from memory your best friends face. [50 marks]

Solution:

Concept:

- A recognisable portrait depends on the remembered relationships of facial features, not on isolated symbols for eyes, nose and mouth. Head shape, hairstyle, feature spacing and characteristic expression carry likeness.
- Treat the head as a three-dimensional form. A centre line and eye line establish orientation, while broad light and shadow planes give volume before fine detail is added.

Step 1: Recall the distinguishing features and choose the pose Before beginning, recall the friend's

head shape, hairline, hairstyle, eyebrow shape, eye spacing, nose length, mouth and usual expression. Choose a near-frontal or gentle three-quarter pose that you can visualise clearly. Place the head comfortably within the page with breathing room above the hair and space in the direction of the gaze. Include the neck and upper shoulders to support the head. Select a familiar relaxed expression rather than an exaggerated smile that would make proportions harder to control. These choices should reflect the particular friend remembered; there is no single prescribed face for this task.

Step 2: Block in the head and locate the features Draw a light overall head shape, then a centre line following its turn and a curved eye line around the form. Establish the jaw, chin, ears and major hair mass before detailing features. Use approximate construction guides only as starting points: the remembered individual proportions should take priority over a rigid generic template. Compare the width of the eyes, the gap between them, the nose-to-mouth spacing and the width of the jaw. In a three-quarter view, make the farther side narrower and keep both eyes on the same turning eye line. Draw the nose as planes and the lips as volumes meeting along a mouth line rather than outlining them as flat icons.

Step 3: Model the face and strengthen the likeness Choose a consistent light from above and to one side. Lay in the large shadow across the turning side of the head, beneath the nose, under the lower lip and below the chin. Keep the whites of the eyes related to the surrounding facial tone, and avoid equally dark outlines around every feature. Build the hair in grouped masses with selective strands following its direction. Use soft transitions over cheeks and sharper accents at the eyelids, nostrils and mouth corners. Recheck the characteristic expression, hairstyle and head-to-neck relationship. Keep the background quiet, sharpen only the most important features and remove unnecessary construction lines without flattening the modelling.

Step 4: Conclusion The final portrait should depict the remembered friend through characteristic head shape, feature proportions, hairstyle and expression, supported by a believable neck and shoulders and consistent tonal modelling. Preserve individual likeness rather than substituting a generic ideal face.

Quick Tip to Solve: Check the big relationships before adding eyelashes or hair strands: silhouette, eye spacing, nose-to-chin length and hairstyle usually improve likeness more than extra detail.