# JEE Main 2023 Paper 2B (B.Planning) Apr 12 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 2B (B.Planning.) of JEE (Main) 2023, Session 2 (April), conducted by the National Testing Agency (NTA) in Computer Based Test (CBT) mode on 12 April 2023, Shift 2. The total duration is 3 hours.

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

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

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

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

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

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

**1. If $f(x) = \frac{x^3}{x-1} + \frac{x^3}{x+1}$ and $g(x) = \sqrt{x}$, then $fog : [0,2] - \{1\} \to \mathbb{R}$ is :** [4 marks]

(A) one-one but not onto

(B) one-one and onto

(C) onto but not one-one

(D) neither one-one nor onto

**Correct Answer:** (A) one-one but not onto

**Solution:**

**Concept:**

- The composite function is obtained by substituting $g(x) = \sqrt{x}$ into $f$; its domain is $[0,1) \cup (1,2]$.
- A function is one-one if distinct inputs have distinct outputs, and onto $\mathbb{R}$ only if its range is all real numbers.

**Step 1:** Simplify the composite Write $h = f \circ g$. Combining the two fractions before substituting gives

$$f(u) = \frac{u^3((u+1)+(u-1))}{u^2-1} = \frac{2u^4}{u^2-1}.$$

Consequently,

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

The excluded value $x = 1$ is essential: the derivative test must be applied on the two separate domain intervals.

**Step 2:** Check injectivity on and between the intervals Differentiate the simplified expression:

$$h'(x) = 2 - \frac{2}{(x-1)^2} = \frac{2x(x-2)}{(x-1)^2}.$$

This is strictly negative for $0 < x < 1$ and for $1 < x < 2$, so the function is strictly decreasing on each interval. On the first interval it starts at $h(0) = 0$ and tends to $-\infty$; on the second it tends from $+\infty$ down to $h(2) = 8$. Thus the two ranges are disjoint. Two inputs in one interval cannot have the same output, and inputs in different intervals have outputs in disjoint ranges.

**Step 3:** Compare the range with the codomain The exact range is

$$(-\infty, 0] \cup [8, \infty).$$

For example, the real number $1$ has no preimage. Thus the composite is not onto the stated codomain. Options (B) and (C) incorrectly assert surjectivity, while option (D) incorrectly denies injectivity.

**Step 4:** Conclusion The composite is one-one but not onto $\mathbb{R}$. Hence, the correct option is (A).

**Quick Tip to Solve:** On a disconnected domain, monotonicity on each piece is not enough: also compare the ranges of the pieces.

**2. The sum of squares of the values of $\alpha \in \mathbb{R}$ such that the argument of $\frac{\alpha+i}{\alpha-i}$ is $60°$, $i = \sqrt{-1}$, is :**

[4 marks]

(A) 3

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

(C) $\frac{11}{3}$

(D) 4

**Correct Answer:** (A) 3

**Solution:**

**Concept:**

- For a nonzero complex number with argument $60°$, both its real and imaginary parts are positive and their ratio is $\sqrt{3}$.
- Multiplying a complex fraction by the conjugate of its denominator exposes its real and imaginary parts without changing its value.

**Step 1:** Separate the real and imaginary parts For every real $\alpha$, the denominator $\alpha - i$ is nonzero. Rationalising gives

$$\frac{\alpha+i}{\alpha-i} = \frac{(\alpha+i)^2}{\alpha^2+1} = \frac{\alpha^2-1}{\alpha^2+1} + i\frac{2\alpha}{\alpha^2+1}.$$

Because $\alpha^2 + 1 > 0$, argument $60°$ requires $\alpha^2 - 1 > 0$ and $\alpha > 0$. Hence any admissible value must satisfy $\alpha > 1$. These sign conditions are necessary because the tangent alone determines an angle only modulo $180°$.

**Step 2:** Solve the tangent equation and enforce the quadrant Equate the imaginary-to-real ratio to $\tan 60°$:

$$\frac{2\alpha}{\alpha^2-1} = \sqrt{3}.$$

Rearranging and factoring yields

$$\sqrt{3}\alpha^2 - 2\alpha - \sqrt{3} = 0, \qquad (\alpha - \sqrt{3})(\sqrt{3}\alpha + 1) = 0.$$

The candidates are $\sqrt{3}$ and $-1/\sqrt{3}$. Only the first is greater than one. At the negative candidate both components are negative, so its principal argument is $-120°$, not $60°$. At $\alpha = \sqrt{3}$, the fraction equals $1/2 + i\sqrt{3}/2$, which directly verifies the required argument.

**Step 3:** Sum only the admissible squares There is therefore exactly one admissible real value, and its squared value is $(\sqrt{3})^2 = 3$. The value $10/3$ would result from retaining the extraneous tangent-equation root. The values $11/3$ and $4$ likewise do not equal the sum over the valid set.

**Step 4:** Conclusion The required sum of squares is $3$. Hence, the correct option is (A).

**Quick Tip to Solve:** After using a tangent equation for an argument, check the signs of both components before accepting its roots.

**3. For the system of equations**

$$x + \lambda y - z = 1$$

$$x + 2y + \lambda z = 2$$

$x + 2y + z = 2$,

**which one of the following is NOT correct?** [4 marks]

(A) it has unique solution if $\lambda$ is not a root of the equation $t^2 - 3t + 2 = 0$

(B) it has unique solution if $\lambda$ is not a root of the equation $t^2 - t - 2 = 0$

(C) it has infinitely many solutions if $\lambda = 1$

(D) it has no solution if $\lambda = 2$

**Correct Answer:** (B) it has unique solution if $\lambda$ is not a root of the equation $t^2 - t - 2 = 0$

**Solution:**

**Concept:**

- A square linear system has a unique solution exactly when its coefficient determinant is nonzero.
- When the determinant vanishes, compare the equations themselves: redundant equations give free variables, whereas contradictory equations give no solution.

**Step 1:** Find the exceptional parameter values The coefficient matrix and its determinant are

$$A = \begin{pmatrix} 1 & \lambda & -1 \\ 1 & 2 & \lambda \\ 1 & 2 & 1 \end{pmatrix}.$$

Subtract the third row from each of the first two rows. Expanding along the resulting second row gives

$$\det A = (\lambda - 2)(\lambda - 1).$$

Hence the system has a unique solution precisely when $\lambda \neq 1, 2$. The polynomial in option (A) is $t^2 - 3t + 2 = (t - 1)(t - 2)$, so option (A) states exactly this correct condition.

**Step 2:** Inspect the singular cases At $\lambda = 1$, the second and third equations coincide, while subtracting the first from the third gives $y + 2z = 1$. One convenient parametrisation is

$$z = s, \qquad y = 1 - 2s, \qquad x = 3s \quad (s \in \mathbb{R}).$$

Every such triple satisfies all three equations, so there are infinitely many solutions and (C) is correct. At $\lambda = 2$, subtracting the third equation from the second gives $z = 0$. But the first and third then require simultaneously $x + 2y = 1$ and $x + 2y = 2$, an impossibility. Therefore (D) is also correct.

**Step 3:** Identify the false condition The polynomial in (B) factors as $t^2 - t - 2 = (t - 2)(t + 1)$. A value $\lambda = 1$ is not a root of this polynomial, but the system then has infinitely many solutions, as just shown. Thus its proposed condition does not ensure uniqueness. This counterexample settles the requested NOT-correct statement without confusing the exceptional values $-1$ and $1$.

**Step 4:** Conclusion Option (B) is the statement that is not correct. Hence, the correct option is (B).

**Quick Tip to Solve:** For a parameterised system, first find determinant zeros, then test each singular value directly in the equations.

---

**4. If $a_n = \left(2n^2 - n + 2\right)(n!)$ then $\sum_{n=1}^{20} a_n$ is equal to :** [4 marks]

(A) $37(20!) - 1$

(B) $37(20!) + 1$

(C) $39(21!) + 1$

(D) $39(21!) - 1$

**Correct Answer:** (C) $39(21!) + 1$

**Solution:**

**Concept:**

- A factorial summand often telescopes when expressed as the difference of two consecutive terms containing $(n+1)!$ and $n!$.
- Use $(n+1)! = (n+1)n!$ to compare a proposed difference with the polynomial multiplying $n!$.

**Step 1:** Construct a consecutive difference Seek a term $b_n = (An+B)(n+1)!$ such that $a_n = b_n - b_{n-1}$. After taking out $n!$, the difference becomes

$$b_n - b_{n-1} = \big[(An+B)(n+1) - (A(n-1)+B)\big]n!.$$

The bracket simplifies to $An^2 + Bn + A$. Matching $2n^2 - n + 2$ gives $A = 2$ and $B = -1$. Thus the appropriate choice is $b_n = (2n-1)(n+1)!$, rather than a multiple of $n!$ alone.

**Step 2:** Verify the identity before summing With that choice,

$$\begin{aligned} a_n &= (2n-1)(n+1)! - (2n-3)n! \\ &= \big[(2n-1)(n+1) - (2n-3)\big]n! \\ &= (2n^2 - n + 2)n!. \end{aligned}$$

For the first index this gives $a_1 = 1 \cdot 2! - (-1) \cdot 1! = 3$, in agreement with the original formula. This check also fixes the sign of the lower boundary term.

**Step 3:** Cancel the interior terms and retain the boundaries Summing from $n = 1$ to 20 cancels every intermediate $b_n$:

$$\sum_{n=1}^{20} a_n = b_{20} - b_0 = 39(21!) - (-1)(1!) = 39(21!) + 1.$$

The lower boundary is negative, so subtracting it adds one. Option (D) has the wrong boundary sign. Options (A) and (B) use 20! and the wrong coefficient; neither matches the surviving upper term $b_{20}$.

**Step 4:** Conclusion The sum is $39(21!) + 1$. Hence, the correct option is (C).

**Quick Tip to Solve:** For a quadratic times a factorial, try a linear factor times the next factorial; verify the first term to catch boundary signs.

---

**5.**

$$\lim_{x\to 0^+} \frac{1}{\sqrt{x}}\left(\frac{1}{\sin x}-\frac{1}{x}\right)$$

[4 marks]

(A) is equal to 0

(B) is equal to $\frac{1}{5}$

(C) is equal to 1

(D) does not exist

**Correct Answer:** (A) is equal to 0

**Solution:**

**Concept:**

- The small-angle expansion is $\sin x = x - x^3/6 + O(x^5)$ as $x \to 0$.
- Cancellation of the two singular terms must be performed before estimating the limit; $x > 0$ makes $\sqrt{x}$ real.

**Step 1:** Combine the singular terms first For small positive $x$, both $x$ and $\sin x$ are nonzero. The given expression can be rewritten exactly as

$$\frac{1}{\sqrt{x}}\left(\frac{1}{\sin x}-\frac{1}{x}\right) = \frac{x-\sin x}{x\sin x\sqrt{x}}.$$

Although each reciprocal separately becomes unbounded, their difference is much smaller. Consequently, treating the original expression as a difference of infinite limits would lose the cancellation that determines the answer.

**Step 2:** Extract the first nonzero order Using the expansion of sine gives

$$x-\sin x = \frac{x^3}{6}+O(x^5), \qquad \sin x = x(1+O(x^2)).$$

Substituting these into the combined fraction yields

$$\frac{x^3/6+O(x^5)}{x^{5/2}(1+O(x^2))} = \sqrt{x}\,\frac{1/6+O(x^2)}{1+O(x^2)}.$$

Here $O(x^m)$ denotes a remainder bounded in magnitude by a fixed constant times $x^m$ near zero. The fraction tends to $1/6$, while the factor $\sqrt{x}$ tends to zero from above.

**Step 3:** Evaluate and compare the alternatives Their product therefore tends to zero. In particular, the cancellation leaves an expression of order $\sqrt{x}$, not a nonzero constant. Thus neither $1/5$ nor $1$ is possible, ruling out (B) and (C). The positive-side expression has the definite finite limit just obtained, so the claim of nonexistence in (D) is also false.

**Step 4:** Conclusion The right-hand limit equals $0$. Hence, the correct option is (A).

**Quick Tip to Solve:** When two reciprocal functions diverge together, combine them and compare the first nonzero powers of the numerator and denominator.

**6. Let $x = x(t)$ be the solution curve of the differential equation $\frac{dx}{dt} = -kx$, and $x(0) = 100$, $x\left(\frac{1}{2}\right) = 80$. If $x(t_\alpha) = 5$, then $t_\alpha$ is equal to :** [4 marks]

(A) $\frac{\log_e 5+\log_e 4}{2(\log_e 5-\log_e 4)}$

(B) $\frac{\log_e 5+\log_e 4}{\log_e 5-\log_e 4}$

(C) $\frac{\log_e 5-\log_e 4}{2(\log_e 5+\log_e 4)}$

(D) $\frac{\log_e 5-\log_e 4}{\log_e 5+\log_e 4}$

**Correct Answer:** (A) $\frac{\log_e 5+\log_e 4}{2(\log_e 5-\log_e 4)}$

**Solution:**

**Concept:**

- The differential equation $dx/dt = -kx$, with constant $k$, has exponential solutions $x(t) = Ce^{-kt}$.
- An initial value determines $C$; a second value determines the decay rate $k$, after which the target time follows by logarithms.

**Step 1:** Solve the equation with the initial condition On the positive solution through $x(0) = 100$, separate variables and integrate:

$$\frac{dx}{x} = -k\,dt, \qquad \ln x = -kt + C_1.$$

Exponentiation and the initial condition give

$$x(t) = 100e^{-kt}.$$

This function remains positive, so division by $x$ and the logarithms used here are valid along the solution. A decreasing value from 100 to 80 at positive time will give $k > 0$, consistent with decay.

**Step 2:** Determine the rate from the half-time observation The datum $x(1/2) = 80$ gives

$$80 = 100e^{-k/2}, \qquad e^{-k/2} = \frac{4}{5}.$$

Taking natural logarithms yields

$$k = 2\ln\frac{5}{4} = 2(\ln 5 - \ln 4).$$

The factor 2 comes from the observation at time $1/2$, and must be retained when finding the later time.

**Step 3:** Find the time at which the value is five Substitute $x(t_\alpha) = 5$:

$$5 = 100e^{-kt_\alpha}, \qquad e^{-kt_\alpha} = \frac{1}{20}.$$

Therefore

$$t_\alpha = \frac{\ln 20}{k} = \frac{\ln 5 + \ln 4}{2(\ln 5 - \ln 4)}.$$

This is positive, as required. Option (B) omits the factor two in the rate. Options (C) and (D) reverse the numerator and denominator structure and do not satisfy $kt_\alpha = \ln 20$; (D) also omits that factor

two.

**Step 4:** Conclusion $t_\alpha = \dfrac{\ln 5 + \ln 4}{2(\ln 5 - \ln 4)}$. Hence, the correct option is (A).

**Quick Tip to Solve:** Use ratios to remove the integration constant, and keep the actual observation time in the logarithmic decay-rate calculation.

---

**7. The slope of the tangent to the curve $y = y(x) = \int_{\sin^{-1}(x)}^{\cos^{-1}(x)} \sqrt{1 + 4\sin^2 t}\, dt; 0 \le x \le 1$ at the point $\left(\frac{1}{\sqrt{2}}, 0\right)$ on the curve is :** [4 marks]

(A) $-2\sqrt{6}$

(B) $2\sqrt{6}$

(C) $-4\sqrt{3}$

(D) $4\sqrt{3}$

**Correct Answer:** (A) $-2\sqrt{6}$

**Solution:**

**Concept:**

- Leibniz differentiation gives $\frac{d}{dx}\int_{a(x)}^{b(x)} F(t)\, dt = F(b(x))b\prime(x) - F(a(x))a\prime(x)$.
- For $-1 < x < 1$, $\frac{d}{dx}\arcsin x = 1/\sqrt{1-x^2}$ and $\frac{d}{dx}\arccos x = -1/\sqrt{1-x^2}$.

**Step 1:** Differentiate both moving endpoints Here $F(t) = \sqrt{1 + 4\sin^2 t}$ is continuous, so the endpoint differentiation rule applies. The upper limit is $\arccos x$, whose derivative is negative; the lower limit is $\arcsin x$, and its contribution is subtracted. Thus

$$y'(x) = -\frac{\sqrt{1 + 4\sin^2(\arccos x)}}{\sqrt{1-x^2}} - \frac{\sqrt{1 + 4\sin^2(\arcsin x)}}{\sqrt{1-x^2}}.$$

Both terms have negative signs. Ignoring the lower endpoint or assigning the same derivative sign to inverse sine and inverse cosine would give an incorrect slope.

**Step 2:** Simplify the endpoint integrands For $0 \le x \le 1$, the inverse angles lie in the first quadrant. Consequently,

$$\sin^2(\arccos x) = 1 - x^2, \qquad \sin^2(\arcsin x) = x^2.$$

Therefore

$$y'(x) = -\frac{\sqrt{5 - 4x^2} + \sqrt{1 + 4x^2}}{\sqrt{1-x^2}}.$$

The specified point is on the curve because, at $x = 1/\sqrt{2}$, both integration limits equal $\pi/4$, making the integral zero.

**Step 3:** Evaluate the slope at the specified point At this input, $x^2 = 1/2$. Both radicals in the numerator equal $\sqrt{3}$, while the denominator equals $1/\sqrt{2}$. Hence

$$y'(1/\sqrt{2}) = -\frac{2\sqrt{3}}{1/\sqrt{2}} = -2\sqrt{6}.$$

The slope is negative, excluding (B) and (D). Option (C) has the incorrect magnitude because the denominator is $1/\sqrt{2}$, not $1/2$.

**Step 4:** Conclusion The tangent slope is $-2\sqrt{6}$. Hence, the correct option is (A).

**Quick Tip to Solve:** For a definite integral with two moving limits, write upper contribution minus lower contribution before inserting endpoint derivatives.

---

**8. Let $\alpha, \beta, \gamma \left(0 < \alpha, \beta, \gamma < \frac{\pi}{2}\right)$ be the angles between non-zero vectors $\vec{a}$ and $\vec{b}, \vec{b}$ and $\vec{c}, \vec{c}$ and $\vec{a}$ respectively. If $\theta$ is the angle that the vector $\vec{a}$ makes with the plane containing $\vec{b}$ and $\vec{c}$, then**

[4 marks]

(A) $\cos^2\theta = \operatorname{cosec}^2\beta\left(\cos^2\alpha + \cos^2\gamma - 2\cos\alpha\cos\beta\cos\gamma\right)$

(B) $\cos^2\theta = \sec^2\beta\left(\cos^2\alpha + \cos^2\gamma + 2\cos\alpha\cos\beta\cos\gamma\right)$

(C) $\sin^2\theta = \operatorname{cosec}^2\beta\left(\cos^2\alpha + \cos^2\gamma - 2\cos\alpha\cos\beta\cos\gamma\right)$

(D) $\sin^2\theta = \sec^2\beta\left(\cos^2\alpha + \cos^2\gamma + 2\cos\alpha\cos\beta\cos\gamma\right)$

**Correct Answer:** (A) $\cos^2\theta = \operatorname{cosec}^2\beta\left(\cos^2\alpha + \cos^2\gamma - 2\cos\alpha\cos\beta\cos\gamma\right)$

**Solution:**

**Concept:**

- If $\theta$ is the angle a unit vector makes with a plane, the squared length of its projection onto that plane is $\cos^2\theta$.
- Choose an orthonormal basis within the plane: one direction along $\vec{b}$, and another perpendicular to it within the plane of $\vec{b}, \vec{c}$.

**Step 1:** Resolve the unit directions in a plane basis Let $\vec{u} = \vec{a}/|\vec{a}|$, $\vec{e}_1 = \vec{b}/|\vec{b}|$, and choose $\vec{e}_2$ in the stated plane perpendicular to $\vec{e}_1$, toward $\vec{c}$. Since $0 < \beta < \pi/2$, the two plane directions are independent and

$$\frac{\vec{c}}{|\vec{c}|} = \cos\beta\,\vec{e}_1 + \sin\beta\,\vec{e}_2.$$

The given angles imply $\vec{u}\cdot\vec{e}_1 = \cos\alpha$ and $\vec{u}\cdot(\vec{c}/|\vec{c}|) = \cos\gamma$. Taking the dot product of the displayed resolution with $\vec{u}$ therefore gives

$$\vec{u}\cdot\vec{e}_2 = \frac{\cos\gamma - \cos\alpha\cos\beta}{\sin\beta}.$$

**Step 2:** Calculate the planar projection length The two orthonormal components add in squares, so

$$\begin{aligned}\cos^2\theta &= \cos^2\alpha + \frac{(\cos\gamma - \cos\alpha\cos\beta)^2}{\sin^2\beta}\\ &= \frac{\cos^2\alpha\sin^2\beta + \cos^2\gamma - 2\cos\alpha\cos\beta\cos\gamma + \cos^2\alpha\cos^2\beta}{\sin^2\beta}\\ &= \operatorname{cosec}^2\beta\left(\cos^2\alpha + \cos^2\gamma - 2\cos\alpha\cos\beta\cos\gamma\right).\end{aligned}$$

We used $\sin^2\beta + \cos^2\beta = 1$ to combine the two $\cos^2\alpha$ terms.

**Step 3:** Match the geometric quantity and signs This is the squared planar projection, so its left side is $\cos^2\theta$, rather than $\sin^2\theta$. That rules out (C) and (D). The perpendicular plane-basis component required division by $\sin\beta$, and expansion gives a negative mixed term; (B) has both the wrong denominator and the wrong mixed-term sign.

**Step 4:** Conclusion The identity stated in option (A) holds. Hence, the correct option is (A).

**Quick Tip to Solve:** For angles between three vectors, normalise them and use an orthonormal basis in the relevant plane to compute the projection.

**9. The domain of the function $f(x) = \sin^{-1}\left(\log_2((x-1)(x-2))\right)$ is :** [4 marks]

(A) $[0, 3]$

(B) $\left[0, \frac{3-\sqrt{3}}{2}\right] \cup \left[\frac{3+\sqrt{3}}{2}, 3\right]$

(C) $\left(\frac{3-\sqrt{3}}{2}, 1\right) \cup \left(2, \frac{3+\sqrt{3}}{2}\right)$

(D) $\left[0, \frac{3-\sqrt{6}}{2}\right] \cup \left[\frac{3+\sqrt{6}}{2}, 3\right]$

**Correct Answer:** (B) $\left[0, \frac{3-\sqrt{3}}{2}\right] \cup \left[\frac{3+\sqrt{3}}{2}, 3\right]$

**Solution:**

**Concept:**

- The real inverse sine function is defined only for inputs in $[-1, 1]$. Thus the entire logarithm, not its argument, must lie in this interval.
- The logarithm to base $2 > 1$ is increasing. Exponentiating an inequality therefore preserves its direction; the resulting lower bound also guarantees a positive logarithmic argument.

**Step 1:** Impose the inverse sine restriction Put $u = (x-1)(x-2)$. The necessary and sufficient condition is

$$-1 \le \log_2 u \le 1.$$

Since the base exceeds one, this is equivalent to

$$\frac{1}{2} \le u \le 2.$$

There is no separate sign ambiguity: $u \ge 1/2$ already ensures that the logarithm exists.

**Step 2:** Solve both quadratic inequalities Using $u = x^2 - 3x + 2$, the upper bound gives

$$x^2 - 3x \le 0 \quad \Longrightarrow \quad x \in [0, 3].$$

The lower bound gives

$$x^2 - 3x + \frac{3}{2} \ge 0.$$

Its roots are $r_- = (3-\sqrt{3})/2$ and $r_+ = (3+\sqrt{3})/2$. Because the leading coefficient is positive, this inequality holds for $x \le r_-$ or $x \ge r_+$.

**Step 3:** Intersect the restrictions and check the options Both conditions must hold simultaneously, so intersect the two exterior intervals with $[0, 3]$. Every endpoint is included: the logarithm becomes $-1$ or $1$, both allowed by inverse sine. Option (A) wrongly includes $x = 1$, where the logarithm fails. Option (C) uses the intervening intervals and excludes valid endpoints. Option (D) has $\sqrt{6}$ instead of the discriminant $\sqrt{3}$.

**Step 4:** Conclusion The domain is $\left[0, \frac{3-\sqrt{3}}{2}\right] \cup \left[\frac{3+\sqrt{3}}{2}, 3\right]$. Hence, the correct option is (B).

**Quick Tip to Solve:** For an inverse sine of a logarithm, bound the logarithm between -1 and 1 first; exponentiation then supplies positivity automatically.

---

**10. Let $\alpha$ and $\beta$ be the roots of the equation $2x^2 - 5x - 1 = 0$. For $n \in \mathbb{N}$, let $P_n = \alpha^n + \beta^n$. Then $\frac{2P_{11}(2P_{10}-5P_9)}{P_8(5P_{10}+P_9)}$ is equal to :** [4 marks]

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

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

(C) $-1$

(D) 1

**Correct Answer:** (D) 1

**Solution:**

**Concept:**

- Each root of $2x^2 - 5x - 1 = 0$ satisfies $2r^2 = 5r + 1$. Multiplying by a suitable power of $r$ produces a recurrence without computing either root.
- Adding the identities for $\alpha$ and $\beta$ gives $2P_n = 5P_{n-1} + P_{n-2}$ for $n \geq 2$, where $P_n = \alpha^n + \beta^n$.

**Step 1:** Derive the recurrence for the power sums For either root $r$, multiply the quadratic identity by $r^{n-2}$:

$$2r^n = 5r^{n-1} + r^{n-2}.$$

Adding the two root equations gives

$$2P_n = 5P_{n-1} + P_{n-2}.$$

This method keeps the expression exact and avoids large powers of irrational root formulas.

**Step 2:** Identify the factors in the expression At $n = 10$, the recurrence yields

$$2P_{10} - 5P_9 = P_8.$$

At $n = 11$, it yields

$$5P_{10} + P_9 = 2P_{11}.$$

Consequently both the numerator and denominator of the requested expression have the same two factors, merely written in different forms.

**Step 3:** Cancel only after checking the denominator The roots are $(5 + \sqrt{33})/4$ and $(5 - \sqrt{33})/4$. The

first is positive and has larger absolute value than the negative second root. Hence $P_{11} > 0$; also $P_8 > 0$, since it is a sum of positive even powers. Cancellation is therefore valid:

$$\frac{2P_{11}(2P_{10} - 5P_9)}{P_8(5P_{10} + P_9)} = \frac{2P_{11}P_8}{P_8(2P_{11})} = 1.$$

The negative alternatives (A) and (C) and the half-valued alternative (B) cannot equal this exact ratio.

**Step 4:** Conclusion The required value is 1. Hence, the correct option is (D).

**Quick Tip to Solve:** When a question contains adjacent power sums of quadratic roots, turn the quadratic equation into a recurrence before expanding powers.

**11. If the image of the point $(1, 1, 2)$ in the plane $2x - y + z + 3 = 0$ is the point P, then the distance of P from origin is** [4 marks]

(A) $2\sqrt{3}$

(B) $3\sqrt{2}$

(C) 4

(D) 6

**Correct Answer:** (B) $3\sqrt{2}$

**Solution:**

**Concept:**

- A plane $ax + by + cz + d = 0$ has normal vector $\mathbf{n} = (a, b, c)$. Reflection moves a point twice its signed normal displacement from the plane.
- For $Q = (x_0, y_0, z_0)$, the reflected point is $Q - 2(ax_0 + by_0 + cz_0 + d)\mathbf{n}/(a^2 + b^2 + c^2)$. The distance from the origin is the Euclidean norm of the reflected point.

**Step 1:** Evaluate the normal displacement Here $Q = (1, 1, 2)$, $\mathbf{n} = (2, -1, 1)$, and $d = 3$. Substitution in the plane expression gives

$$2(1) - 1 + 2 + 3 = 6, \qquad \mathbf{n} \cdot \mathbf{n} = 4 + 1 + 1 = 6.$$

Thus the scalar multiplying the normal in the reflection formula is $2(6)/6 = 2$. The constant term of the plane must be retained in this calculation.

**Step 2:** Find and verify the reflected point Therefore

$$P = (1, 1, 2) - 2(2, -1, 1) = (-3, 3, 0).$$

Its midpoint with $Q$ is $M = (-1, 2, 1)$, which lies on the plane because $2(-1) - 2 + 1 + 3 = 0$. Moreover $P - Q = (-4, 2, -2) = -2\mathbf{n}$, so the segment joining a point to its image is perpendicular to the plane. These two checks verify the reflection rather than merely a projection.

**Step 3:** Compute the distance required The question asks for the distance of $P$ from the origin, not

the distance of $Q$ from the plane. Hence

$$OP = \sqrt{(-3)^2 + 3^2 + 0^2} = \sqrt{18} = 3\sqrt{2}.$$

Squaring the listed distances gives $12, 18, 16, 36$, respectively. Only option (B) agrees with the computed squared norm $18$; the other options therefore fail directly.

**Step 4:** Conclusion The distance of the image from the origin is $3\sqrt{2}$. Hence, the correct option is (B).

**Quick Tip to Solve:** After reflecting a point, verify that its midpoint with the original lies on the plane and that their joining vector is normal to it.

---

**12. For three non-coplanar vectors $\vec{a}, \vec{b}, \vec{c}$, if $(\vec{b}+\vec{c}) \cdot \{(\vec{c}+\vec{a}) \times (\vec{a}+\vec{b})\} = \alpha[\vec{a}\ \vec{b}\ \vec{c}]$ and $(\vec{a}+\vec{b}) \cdot \{(\vec{b}+\vec{c}) \times (\vec{a}+\vec{b}+\vec{c})\} = \beta[\vec{a}\ \vec{b}\ \vec{c}]$, then $\alpha+\beta$ is equal to :** [4 marks]

(A) $-3$

(B) $-1$

(C) 1

(D) 3

**Correct Answer:** (D) 3

**Solution:**

**Concept:**

- The scalar triple product $[\mathbf{u}\ \mathbf{v}\ \mathbf{w}] = \mathbf{u} \cdot (\mathbf{v} \times \mathbf{w})$ is multilinear and alternating. Repeated vectors make a term zero.
- For three linear combinations of $\vec{a}, \vec{b}, \vec{c}$, the triple product is the determinant of their coefficient rows times $[\vec{a}\ \vec{b}\ \vec{c}]$. Non-coplanarity ensures that this common factor is nonzero.

**Step 1:** Calculate the coefficient for the first product Use the ordered basis $(\vec{a}, \vec{b}, \vec{c})$. The coefficient rows of $\vec{b}+\vec{c}$, $\vec{c}+\vec{a}$, and $\vec{a}+\vec{b}$ are respectively $(0,1,1)$, $(1,0,1)$, and $(1,1,0)$. Thus

$$\alpha = \begin{vmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{vmatrix} = 0 - 1(0-1) + 1(1-0) = 2.$$

The ordering of the rows is the ordering of the dot and cross product in the question; changing two rows would reverse the sign.

**Step 2:** Calculate the coefficient for the second product The second product has ordered vectors $\vec{a}+\vec{b}$, $\vec{b}+\vec{c}$, and $\vec{a}+\vec{b}+\vec{c}$. Therefore

$$\beta = \begin{vmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{vmatrix} = 1(1-1) - 1(0-1) = 1.$$

This can also be seen by subtracting the first row from the third, which does not change the determi-

nant.

**Step 3:** Combine the values and rule out the other signs Since the original vectors are non-coplanar, their scalar triple product is nonzero and the coefficients are uniquely determined. We obtain

$$\alpha + \beta = 2 + 1 = 3.$$

Option (A) would reverse both determinant signs. Options (B) and (C) do not equal the sum of the two independently computed coefficients. Only option (D) matches the given order of the triple products.

**Step 4:** Conclusion We have $\alpha = 2$, $\beta = 1$, and $\alpha + \beta = 3$. Hence, the correct option is (D).

**Quick Tip to Solve:** Write coefficient rows in exactly the order of the scalar triple product; this prevents sign errors caused by swapping the cross-product factors.

---

**13. If $I(x) = \int \frac{dx}{1-2\sin^2 x \cos^2 x}$, then $\tan\left(\sqrt{2}\left(I\left(\frac{\pi}{8}\right) - I(0)\right)\right)$ is equal to :** [4 marks]

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

(B) 1

(C) $\sqrt{2}$

(D) 2

**Correct Answer:** (A) $\frac{1}{\sqrt{2}}$

**Solution:**

**Concept:**

- Use $2\sin x \cos x = \sin 2x$ to rewrite the denominator as $1 - \frac{1}{2}\sin^2 2x$. This suggests the substitution $t = \tan 2x$.
- The difference $I(\pi/8) - I(0)$ is the definite integral over $[0, \pi/8]$. The arbitrary antiderivative constant cancels, and $\tan 2x$ is continuous on this interval.

**Step 1:** Transform the definite integral Let $J = I(\pi/8) - I(0)$. With $t = \tan 2x$, we have

$$\sin^2 2x = \frac{t^2}{1+t^2}, \qquad dx = \frac{dt}{2(1+t^2)}.$$

The lower and upper limits become $0$ and $1$. Also

$$1 - \frac{1}{2}\sin^2 2x = \frac{2+t^2}{2(1+t^2)}.$$

Dividing the transformed differential by this denominator cancels the common factors exactly.

**Step 2:** Evaluate the elementary integral It follows that

$$J = \int_0^1 \frac{dt}{t^2+2} = \frac{1}{\sqrt{2}}\left[\tan^{-1}\left(\frac{t}{\sqrt{2}}\right)\right]_0^1.$$

Therefore

$$\sqrt{2}J = \tan^{-1}\left(\frac{1}{\sqrt{2}}\right).$$

The arctangent is on its principal continuous branch here, since its argument runs from zero to a positive finite value. No jump by a multiple of $\pi$ occurs.

**Step 3:** Apply the outer tangent and compare Applying tangent gives

$$\tan(\sqrt{2}J) = \frac{1}{\sqrt{2}}.$$

Option (B) would require an arctangent argument of one, while options (C) and (D) are still larger. The transformed upper limit is $t = 1$, but the antiderivative contains $t/\sqrt{2}$; forgetting this scale is what leads to those incorrect choices. The factor from $dt/dx = 2\sec^2 2x$ is also essential.

**Step 4:** Conclusion The required value is $1/\sqrt{2}$. Hence, the correct option is (A).

**Quick Tip to Solve:** For a denominator involving the square of sin 2x, try tan 2x and transform the limits immediately to keep factors of two under control.

**14. Let X have a binomial distribution B $(6, \mathrm{p})$. If the sum of the mean and the variance of X is $\frac{21}{8}$, then $\frac{P(2\le X<4)}{P(4<X<6)}$ is equal to :** [4 marks]

(A) 65

(B) 195

(C) $\frac{195}{2}$

(D) $\frac{225}{2}$

**Correct Answer:** (C) $\frac{195}{2}$

**Solution:**

**Concept:**

- For $X \sim B(n, p)$, the mean is $np$, the variance is $np(1-p)$, and $P(X = k) = \binom{n}{k}p^k(1-p)^{n-k}$.
- Binomial random variables take integer values. Thus $2 \le X < 4$ means $X = 2$ or 3, whereas $4 < X < 6$ means only $X = 5$.

**Step 1:** Find the admissible probability parameter The given sum of mean and variance gives

$$6p + 6p(1-p) = \frac{21}{8}.$$

Dividing by six and rearranging,

$$p^2 - 2p + \frac{7}{16} = 0.$$

The roots are $p = 1 \pm 3/4$, namely $1/4$ and $7/4$. Since a probability lies in $[0, 1]$, we must use $p = 1/4$. Write $q = 1 - p = 3/4$, so $q/p = 3$.

**Step 2:** Write the exact event probabilities The numerator is

$$P(X=2)+P(X=3)=15p^2q^4+20p^3q^3,$$

while the denominator is

$$P(X=5)=6p^5q.$$

The strict inequalities in the denominator exclude both $X=4$ and $X=6$; including either would change the problem. The denominator is positive because $0<p,q<1$.

**Step 3:** Simplify the ratio using the odds Cancel the common powers rather than evaluating small decimal probabilities:

$$\begin{aligned}\frac{15p^2q^4+20p^3q^3}{6p^5q}&=\frac{15}{6}\left(\frac{q}{p}\right)^3+\frac{20}{6}\left(\frac{q}{p}\right)^2\\&=\frac{15(27)+20(9)}{6}=\frac{585}{6}=\frac{195}{2}.\end{aligned}$$

This is neither $65$ nor $195$, so (A) and (B) fail. Option (D), $225/2$, also differs from the exact combinatorial sum. Only (C) agrees.

**Step 4:** Conclusion The required probability ratio is $195/2$. Hence, the correct option is (C).

**Quick Tip to Solve:** Translate strict bounds into the allowed integer outcomes before using binomial probabilities; simplify a ratio with q/p to avoid large fractions.

**15. If the statement**

$$((\mathrm{p}*(\sim \mathrm{q}))\wedge(\mathrm{p}\vee \mathrm{q}))\Leftrightarrow \mathrm{p}$$

**is a tautology, then $*$ is :** [4 marks]

(A) $\wedge$

(B) $\vee$

(C) $\Rightarrow$

(D) $\Leftrightarrow$

**Correct Answer:** (B) $\vee$

**Solution:**

**Concept:**

- A biconditional is a tautology when its two sides have the same truth value for every assignment of $p$ and $q$. Here the left side must reduce identically to $p$.
- The distributive identity $(p\vee r)\wedge(p\vee s)=p\vee(r\wedge s)$, together with $\neg q\wedge q$ being false, provides a direct test of the disjunction option.

**Step 1:** Test disjunction by simplifying the expression Take $*=\vee$. Then the left side of the

biconditional becomes

$$(p \vee \neg q) \wedge (p \vee q) = p \vee (\neg q \wedge q)$$
$$= p \vee \text{False} = p.$$

Hence the full statement is $p \Leftrightarrow p$, which is true for every truth assignment. This proves that option (B) works without relying on a few examples.

**Step 2:** Eliminate conjunction and implication For $* = \wedge$, the left side is $(p \wedge \neg q) \wedge (p \vee q)$. Taking $p = \text{True}$ and $q = \text{True}$ makes it false while $p$ is true, so option (A) fails. For $* = \Longrightarrow$, use $p = \text{False}$, $q = \text{True}$. The implication $p \Rightarrow \neg q$ is true, and $p \vee q$ is true. Thus the left side is true while $p$ is false, disproving option (C).

**Step 3:** Eliminate the remaining biconditional choice For $* = \Leftrightarrow$, take $p = \text{True}$, $q = \text{True}$. Then $\neg q$ is false, so $p \Leftrightarrow \neg q$ is false. Its conjunction with $p \vee q$ remains false, which disagrees with the true right side $p$. Thus option (D) also fails. A single counterexample rules out each incorrect connective, whereas the algebraic identity establishes the successful choice universally.

**Step 4:** Conclusion The connective is disjunction, $* = \vee$. Hence, the correct option is (B).

**Quick Tip to Solve:** Prove a tautology by simplifying it for all truth assignments; reject a proposed connective as soon as one assignment makes the two sides differ.

---

**16. If the circles $x^2 + y^2 - 2x - 4y + 4 = 0$ and $x^2 + y^2 - 6x - 10y + 20 + 2\sqrt{13} = 0$ touch each other at the point $(a, \text{b})$, then $(3a - 2\text{b})^2$ is equal to :** [4 marks]

(A) 1

(B) 4

(C) 9

(D) 13

**Correct Answer:** (A) 1

**Solution:**

**Concept:**

- For $x^2 + y^2 + 2gx + 2fy + c = 0$, the centre is $(-g, -f)$ and the radius is $\sqrt{g^2 + f^2 - c}$. At tangency, both centres and the contact point are collinear.
- For externally tangent circles with centre separation $d = r_1 + r_2$, the contact point lies a distance $r_1$ from the first centre towards the second.

**Step 1:** Find the centres and radii Completing squares for the first circle gives

$$(x - 1)^2 + (y - 2)^2 = 1,$$

so $C_1 = (1, 2)$, $r_1 = 1$. The second becomes

$$(x - 3)^2 + (y - 5)^2 = 14 - 2\sqrt{13} = (\sqrt{13} - 1)^2.$$

Thus $C_2 = (3, 5)$, $r_2 = \sqrt{13} - 1$, where the radius is positive because $\sqrt{13} > 1$.

**Step 2:** Locate the contact point The distance between the centres is

$$d = \sqrt{(3-1)^2 + (5-2)^2} = \sqrt{13} = r_1 + r_2.$$

They are externally tangent. The unit vector from $C_1$ to $C_2$ is $(2,3)/\sqrt{13}$. Moving one radius from $C_1$ along it gives

$$(a, b) = \left(1 + \frac{2}{\sqrt{13}},\ 2 + \frac{3}{\sqrt{13}}\right).$$

Using the opposite direction would give the far side of the first circle and would not lie at the contact point.

**Step 3:** Evaluate the requested combination Substitute the contact coordinates:

$$3a - 2b = 3 + \frac{6}{\sqrt{13}} - 4 - \frac{6}{\sqrt{13}} = -1,$$
$$(3a - 2b)^2 = 1.$$

The irrational terms cancel because the linear form $3x - 2y$ is constant along the line of centres, whose direction is $(2,3)$. Options (B), (C), and (D) give $4, 9, 13$, none equal to the resulting square.

**Step 4:** Conclusion The value of $(3a - 2b)^2$ is $1$. Hence, the correct option is (A).

**Quick Tip to Solve:** When the requested linear combination is perpendicular to the line of centres, it has the same value at the contact point as at either centre.

---

**17. If the angle between the line $l : \frac{x-1}{2} = \frac{y+1}{1} = \frac{z-2}{2}$ and the plane $\mathrm{P} : \lambda x + 4\mathrm{y} - 7 = 0, \lambda \neq 0$, is $\mathrm{cosec}^{-1}\left(\frac{3}{2}\right)$, then the sum of co-ordinates of the point where line $l$ crosses the plane P is :** [4 marks]

(A) $-33$

(B) $-2$

(C) 3

(D) 6

**Correct Answer:** (D) 6

**Solution:**

**Concept:**

- The direction vector of the line is $\mathbf{d} = (2,1,2)$, while a normal to the plane is $\mathbf{n} = (\lambda, 4, 0)$. The angle with the plane is complementary to the angle with its normal.
- For the acute line-plane angle $\theta$, $\sin\theta = |\mathbf{d} \cdot \mathbf{n}|/(|\mathbf{d}||\mathbf{n}|)$. Here $\theta = \mathrm{cosec}^{-1}(3/2)$, so $\sin\theta = 2/3$.

**Step 1:** Determine the plane parameter The direction vector has length $\sqrt{4+1+4} = 3$. Consequently the angle condition becomes

$$\frac{|2\lambda + 4|}{3\sqrt{\lambda^2 + 16}} = \frac{2}{3}.$$

Both sides are nonnegative, so squaring introduces no sign ambiguity provided the result is checked.

Cancelling the common factor and squaring gives

$$(\lambda+2)^2=\lambda^2+16, \qquad 4\lambda+4=16, \qquad \lambda=3.$$

This satisfies the stated nonzero restriction. Substitution gives $10/(3\cdot5)=2/3$, confirming the angle.

**Step 2:** Intersect the line with the plane Introduce a single parameter $t$ for all three coordinate ratios:

$$x=1+2t, \qquad y=-1+t, \qquad z=2+2t.$$

The plane is now $3x+4y-7=0$. Substitution yields

$$3(1+2t)+4(-1+t)-7=0 \quad \Longrightarrow \quad 10t-8=0.$$

Thus $t=4/5$, and the intersection is $(13/5,-1/5,18/5)$. Its coordinate sum is $(13-1+18)/5=6$. The other listed sums, $-33,-2,3$, do not equal the sum of this unique intersection.

**Step 3:** Conclusion The required sum is $\boxed{6}$. Hence, the correct option is (D).

**Quick Tip to Solve:** Use the sine of the line-plane angle; the cosine formula instead gives the angle with the plane normal.

**18. Let three distinct normal be drawn to the parabola $y^2+4y-6x-8=0$ from a point $(a,\mathrm{b})$ on the axis of the parabola. Then :** [4 marks]

(A) $a\in(1,\infty)$ and $b=-2$

(B) $a\in(0,\infty)$ and $b=-2$

(C) $a\in(1,\infty)$ and $b=2$

(D) $a\in(2,\infty)$ and $b=2$

**Correct Answer:** (A) $a\in(1,\infty)$ and $b=-2$

**Solution:**

**Concept:**

- Complete the square to identify the vertex and axis before applying a standard normal equation. Translation preserves the number of normals through a point.
- For $Y^2=4cX$, the point with parameter $t$ is $(ct^2,2ct)$, and its normal is $Y=-tX+2ct+ct^3$. Distinct real parameters give distinct normal contact points.

**Step 1:** Translate to standard coordinates The given equation can be rearranged as

$$(y+2)^2=6x+12=6(x+2).$$

Set $X=x+2$ and $Y=y+2$. Then $Y^2=6X=4cX$, with $c=3/2$. The axis is $Y=0$, or $y=-2$. Since the point $(a,b)$ lies on this axis, necessarily $b=-2$. In translated coordinates it is $(a+2,0)$. In particular, either option with $b=2$ is immediately excluded.

**Step 2:** Require three distinct real normals Substituting $(X,Y)=(a+2,0)$ into the normal equation

gives

$$0 = -t(a+2) + 3t + \frac{3}{2}t^3 = t\left(1 - a + \frac{3}{2}t^2\right).$$

One real root is always $t = 0$, corresponding to the axis normal. The other roots satisfy

$$t^2 = \frac{2}{3}(a-1).$$

There are two additional distinct real roots precisely when $a - 1 > 0$. If $a = 1$, all three algebraic roots coincide at zero, so they do not represent three distinct normals. If $a < 1$, the two nonzero roots are not real. Hence the exact condition is $a > 1$, together with $b = -2$. Option (B) incorrectly includes $0 < a \leq 1$, and (C), (D) use the wrong axis.

**Step 3:** Conclusion Three distinct normals exist for $\boxed{a \in (1, \infty),\ b = -2}$. Hence, the correct option is (A).

**Quick Tip to Solve:** For a point on a parabola axis, factor the normal cubic by the zero parameter and check that the remaining squared parameter is strictly positive.

---

**19. Given ${}^{n}c_r = \frac{n!}{r!(n-r)!}$, $0 \leq \mathrm{r} \leq \mathrm{n}$ and n is a non-negative integer. Then a possible value of k for which the equality**

${}^{50}\mathrm{C}_{\mathrm{k}-1} + \sum_{r=1}^{50} {}^{100-r}\mathrm{C}_{\mathrm{k}-2} = {}^{100}\mathrm{C}_{49}$ **holds, is** [4 marks]

(A) 40

(B) 49

(C) 50

(D) 25

**Correct Answer:** (C) 50

**Solution:**

**Concept:**

- Pascal's identity $\binom{j+1}{m+1} = \binom{j}{m+1} + \binom{j}{m}$ converts a sum along a binomial diagonal into a telescoping difference.
- The symmetry $\binom{N}{r} = \binom{N}{N-r}$ provides a second index giving the same coefficient. Consecutive coefficients increase strictly up to the middle of an even row.

**Step 1:** Rewrite the summation with increasing upper indices Put $j = 100 - r$. As $r$ goes from 1 to 50, $j$ runs through the integers 99 down to 50. Therefore the left side is

$$\binom{50}{k-1} + \sum_{j=50}^{99} \binom{j}{k-2}.$$

Apply Pascal's identity in difference form:

$$\binom{j}{k-2} = \binom{j+1}{k-1} - \binom{j}{k-1}.$$

Adding these differences cancels every intermediate coefficient, leaving $\binom{100}{k-1} - \binom{50}{k-1}$. The separate first term cancels the remaining subtraction.

**Step 2:** Compare the resulting coefficient with the target The required equality is consequently

$$\binom{100}{k-1} = \binom{100}{49}.$$

Taking $k-1 = 49$ gives $k = 50$, which is admissible in every original binomial coefficient. The symmetric index $k-1 = 51$ is inadmissible because $\binom{50}{51}$ is undefined under the stated definition. To reject the remaining choices, their lower indices are 39, 48 and 24. All are below 49, and the coefficients are strictly increasing there because

$$\frac{\binom{100}{j+1}}{\binom{100}{j}} = \frac{100-j}{j+1} > 1 \qquad (j < 49).$$

They therefore cannot equal $\binom{100}{49}$. This also checks the index shift: it is $k-1$, rather than $k$, which becomes the final lower index.

**Step 3:** Conclusion A possible listed value is $\boxed{k = 50}$. Hence, the correct option is (C).

**Quick Tip to Solve:** When upper binomial indices vary consecutively, try Pascal's identity in difference form and retain the boundary terms carefully.

**20. If an unbiased die, marked with $-3, -2, -1, 0, 1, 2$ on its faces, is thrown four times, then the probability of getting $-1$ as the sum of outputs is :** [4 marks]

(A) $\frac{7}{81}$
(B) $\frac{35}{324}$
(C) $\frac{8}{81}$
(D) $\frac{26}{243}$

**Correct Answer:** (B) $\frac{35}{324}$

**Solution:**

**Concept:**

- Four independent throws of a fair six-faced die give $6^4$ equally likely ordered outcomes. Order matters because each position records a different throw.
- Translating each face value by 3 changes the permitted values to $0, 1, 2, 3, 4, 5$. Stars and bars counts nonnegative solutions, and inclusion-exclusion removes solutions above 5.

**Step 1:** Translate the target sum Write the original outputs as $x_1, x_2, x_3, x_4$, and put $u_i = x_i + 3$. Each $u_i$ is an integer between 0 and 5. The condition $x_1 + x_2 + x_3 + x_4 = -1$ becomes

$$u_1 + u_2 + u_3 + u_4 = 11.$$

Ignoring the upper bounds temporarily, the number of nonnegative ordered solutions is

$$\binom{11+4-1}{4-1} = \binom{14}{3} = 364.$$

This counts ordered throws directly; no additional permutation factor should be inserted.

**Step 2:** Remove the outcomes violating the upper bounds If a specified $u_i$ is at least 6, subtract 6 from that variable. The remaining sum is 5, giving $\binom{8}{3} = 56$ nonnegative solutions. There are four choices of the offending variable. Two variables cannot both be at least 6 because their sum would already exceed 11. Hence inclusion-exclusion stops after this subtraction:

$$N = 364 - 4(56) = 140.$$

The required probability is

$$\frac{140}{6^4} = \frac{140}{1296} = \frac{35}{324}.$$

For comparison, the other proposed probabilities correspond to 112, 128 and $416/3$ favourable outcomes out of 1296. None matches the exact count 140; the last is not even an integer count for this equally likely sample space.

**Step 3:** Conclusion The probability is $\boxed{35/324}$. Hence, the correct option is (B).

**Quick Tip to Solve:** Translate consecutive negative die labels to start at zero, then use bounded stars and bars rather than listing four-throw arrangements.

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

*Attempt any 5 of the 10 questions in this section.*

**21.** $(\sin 5^\circ \sin 55^\circ \sin 65^\circ \sin 75^\circ)^{-1}$ **is equal to _____.** [4 marks]

**Solution:**

**Concept:**

- The triple-angle product identity is $\sin 3\theta = 4\sin\theta \sin(60^\circ + \theta)\sin(60^\circ - \theta)$. It groups three sine factors separated symmetrically about $60^\circ$.
- Complementary angles satisfy $\sin(90^\circ - \theta) = \cos\theta$, and $2\sin\theta\cos\theta = \sin 2\theta$. All angles here are in degrees.

**Step 1:** Combine the three factors about sixty degrees Take $\theta = 5^\circ$ in the triple-angle product identity. The angles $60^\circ - 5^\circ = 55^\circ$ and $60^\circ + 5^\circ = 65^\circ$ occur exactly in the question. Thus

$$4\sin 5^\circ \sin 55^\circ \sin 65^\circ = \sin 15^\circ,$$

so the product of these first three factors is $\sin 15^\circ/4$. One can verify the identity from product-to-sum: $\sin(60^\circ + \theta)\sin(60^\circ - \theta) = \sin^2 60^\circ - \sin^2\theta = 3/4 - \sin^2\theta$. Multiplication by $4\sin\theta$ gives $3\sin\theta - 4\sin^3\theta = \sin 3\theta$.

**Step 2:** Use the complementary fourth angle and take the reciprocal Since $75^\circ = 90^\circ - 15^\circ$, the

remaining sine equals $\cos 15^\circ$. Therefore

$$\sin 5^\circ \sin 55^\circ \sin 65^\circ \sin 75^\circ = \frac{1}{4}\sin 15^\circ \cos 15^\circ$$
$$= \frac{1}{8}\sin 30^\circ = \frac{1}{16}.$$

Every original factor is positive and nonzero, so its product has a well-defined positive reciprocal. The exponent $-1$ in the question asks for that reciprocal, rather than an inverse trigonometric angle. Taking it gives $(1/16)^{-1} = 16$. No decimal approximation or rounding is needed.

**Step 3:** Conclusion The required numerical value is $\boxed{16}$, a dimensionless number.

**Quick Tip to Solve:** Look first for the three angles $\theta, 60^\circ - \theta, 60^\circ + \theta$; their product collapses to $\sin 3\theta/4$.

**22. If the shortest distance between the lines $3x+2y-4z-5 = 0 = 5x-7y-17z+2$ and $\frac{x-2}{3} = \frac{y-1}{-5} = \frac{z+1}{2}$ is $\frac{10}{\sqrt{k}}$, then $k$ is equal to _____.** [4 marks]

**Solution:**

**Concept:**

- A line given as the intersection of two planes has a direction vector perpendicular to both plane normals, obtained from their cross product.
- For lines through $A, B$ with nonparallel directions $\mathbf{d}_1, \mathbf{d}_2$, their shortest distance is $D = |(B - A) \cdot (\mathbf{d}_1 \times \mathbf{d}_2)|/|\mathbf{d}_1 \times \mathbf{d}_2|$.

**Step 1:** Find a point and direction on each line The first line is the common intersection of the planes with normals $(3, 2, -4)$ and $(5, -7, -17)$. Their cross product is

$$(-62, 31, -31) = -31(2, -1, 1).$$

We may therefore use $\mathbf{d}_1 = (2, -1, 1)$; multiplying a direction by any nonzero scalar describes the same line. Setting $z = 0$ in the two plane equations gives $3x + 2y = 5$ and $5x - 7y = -2$, whose solution is $x = y = 1$. Hence take $A = (1, 1, 0)$. The second line directly supplies $B = (2, 1, -1)$ and $\mathbf{d}_2 = (3, -5, 2)$.

**Step 2:** Evaluate the scalar triple product The perpendicular direction common to both lines is

$$\mathbf{d}_1 \times \mathbf{d}_2 = (3, -1, -7), \qquad |\mathbf{d}_1 \times \mathbf{d}_2| = \sqrt{9 + 1 + 49} = \sqrt{59}.$$

The displacement between our chosen points is $B - A = (1, 0, -1)$, so its scalar product with this common perpendicular is

$$(1, 0, -1) \cdot (3, -1, -7) = 3 + 7 = 10.$$

Consequently $D = 10/\sqrt{59}$. The nonzero cross product confirms the directions are not parallel, and the nonzero triple product confirms these lines do not intersect. Comparing this exact positive distance with the specified $10/\sqrt{k}$ gives $\sqrt{k} = \sqrt{59}$.

**Step 3:** Conclusion The shortest distance is $10/\sqrt{59}$ coordinate units, and the requested dimensionless value is $\boxed{k = 59}$.

**Quick Tip to Solve:** For a line specified by two planes, first cross their normals; using either plane normal itself as the line direction gives the wrong distance.

**23. For $p \in \mathbb{N}$, if the angle between pair of tangents drawn to the ellipse $3x^2 + 2y^2 = 5$ from the point $(1, p)$ is $\tan^{-1}\left(\frac{12}{\sqrt{5}}\right)$, then the distance of the vertex of the parabola $y = x^2 - px + p + 1$ from the point $(-7, 8)$ is equal to _____.** [4 marks]

**Solution:**

**Concept:**

- For the ellipse $x^2/A^2 + y^2/B^2 = 1$, a line $y = mx + c$ is tangent when $c^2 = A^2m^2 + B^2$. This follows by requiring a repeated intersection root.
- For tangent slopes $m_1, m_2$, $\tan\theta = |(m_1 - m_2)/(1 + m_1m_2)|$. The vertex of $y = x^2 - px + p + 1$ is $(p/2, p + 1 - p^2/4)$.

**Step 1:** Form the equation for the two tangent slopes The ellipse has $A^2 = 5/3$, $B^2 = 5/2$. A line through $(1, p)$ is $y = mx + p - m$, so tangency requires

$$(p - m)^2 = \frac{5}{3}m^2 + \frac{5}{2}, \quad \text{or} \quad \frac{2}{3}m^2 + 2pm + \frac{5}{2} - p^2 = 0.$$

Thus $m_1 + m_2 = -3p$, $m_1m_2 = 15/4 - 3p^2/2$, and $(m_1 - m_2)^2 = 15(p^2 - 1)$. The point must yield two distinct real tangents, so $p > 1$ for natural $p$.

**Step 2:** Determine the natural value of the parameter Using the angle in the question gives

$$\frac{\sqrt{15(p^2 - 1)}}{|19/4 - 3p^2/2|} = \frac{12}{\sqrt{5}}.$$

Squaring and writing $u = p^2$ yields

$$75(u - 1) = 9(19 - 6u)^2, \quad 108u^2 - 709u + 1108 = 0, \quad (u - 4)(108u - 277) = 0.$$

The value $277/108$ is not an integer square, whereas $u = 4$ gives the natural parameter $p = 2$. Substitution into the unsquared equation confirms the angle: $\sqrt{45}/(5/4) = 12/\sqrt{5}$.

**Step 3:** Find the vertex and its distance At $p = 2$, the parabola is $y = x^2 - 2x + 3 = (x - 1)^2 + 2$, with vertex $(1, 2)$. Its distance from $(-7, 8)$ is

$$\sqrt{(1 + 7)^2 + (2 - 8)^2} = \sqrt{64 + 36} = 10.$$

The distance is positive; the coordinate differences, rather than the coordinates themselves, belong in the distance formula.

**Step 4:** Conclusion The vertex is $(1, 2)$, and its required distance is $\boxed{10}$ coordinate units.

**Quick Tip to Solve:** Obtain the sum and product of tangent slopes from their quadratic; the angle formula then avoids solving for either slope individually.

**24. Let P be a polygon with $n$ vertices such that the line segment joining any two points of P remains entirely in P. If the number of diagonals of P is $n + 25$, then $n$ is equal to _____.** [4 marks]

**Solution:**

**Concept:**

- The given segment property means the polygon is convex: joining any two of its points never leaves it. Every pair of distinct vertices therefore determines a side or an internal diagonal.
- An $n$-vertex polygon has $\binom{n}{2} = n(n-1)/2$ unordered vertex pairs and exactly $n$ sides. Its diagonal count is therefore $n(n-3)/2$.

**Step 1:** Translate the diagonal count into an equation There are $n-1$ other vertices available from each vertex. Two are adjacent and give sides, while the remaining $n-3$ give diagonals. Counting from every vertex gives $n(n-3)$, but each diagonal is counted twice, once from each endpoint. Hence

$$\text{number of diagonals} = \frac{n(n-3)}{2}.$$

Equivalently, subtracting the $n$ sides from $\binom{n}{2}$ gives the same result. The question says this count equals $n + 25$, so the required equation is

$$\frac{n(n-3)}{2} = n + 25.$$

**Step 2:** Solve and impose the polygon restriction Multiply by 2 and collect the terms:

$$n^2 - 3n = 2n + 50, \qquad n^2 - 5n - 50 = 0.$$

Factoring gives

$$(n-10)(n+5) = 0.$$

Thus the algebraic candidates are $n = 10$ and $n = -5$. A number of vertices must be a positive integer at least 3, so the negative root is inadmissible. To check the remaining root directly, a decagon has $\binom{10}{2} = 45$ vertex pairs; removing its 10 sides leaves 35 diagonals. The supplied expression also gives $10 + 25 = 35$, so it agrees exactly. The convexity condition ensures the usual meaning of all these diagonals inside the polygon, and no extra restriction changes this count.

**Step 3:** Conclusion The polygon has $\boxed{n = 10}$ vertices. This count is dimensionless.

**Quick Tip to Solve:** Count unordered pairs of vertices and subtract the sides, or count $n-3$ diagonals from each vertex and divide by two.

**25. Let $f(x)$ be a polynomial of degree 5 such that $\lim_{x\to 0}\frac{f(x)}{x^2}=1$, $f(-1)=-1$, $f(x)-14x$ has an extrema at $x=1$ and $f(x)-10x$ has an extrema at $x=-1$. Then $f(2)$ is equal to _____.** [4 marks]

**Solution:**

**Concept:**

- The finite limit $f(x)/x^2 \to 1$ forces the constant and linear coefficients to vanish and the quadratic coefficient to equal one.
- For a differentiable function, an interior local extremum has zero first derivative. Thus the two extremum conditions give values of $f\prime$.

**Step 1:** Write the restricted polynomial Let $f(x)=ax^5+bx^4+cx^3+x^2$, with $a\neq 0$. Substituting $x=-1$ into the given value yields $-a+b-c+1=-1$, hence

$$a-b+c=2.$$

The limit has already used all information about the lower-degree terms; they cannot be added as independent unknowns.

**Step 2:** Use both derivative conditions For $f(x)-14x$, stationarity at 1 gives $f\prime(1)=14$. Similarly $f\prime(-1)=10$. Since $f\prime(x)=5ax^4+4bx^3+3cx^2+2x$, these become

$$5a+4b+3c=12, \qquad 5a-4b+3c=12.$$

Subtracting gives $8b=0$, so $b=0$. The remaining equations are $a+c=2$ and $5a+3c=12$. Subtracting three times the former from the latter gives $2a=6$, hence $a=3, c=-1$.

**Step 3:** Check the extrema and evaluate Therefore $f(x)=3x^5-x^3+x^2$. Its second derivative is $f\prime\prime(x)=60x^3-6x+2$, with values 56 at 1 and -52 at -1. Both are nonzero, so the stationary points really are extrema of the corresponding functions, rather than stationary inflections. Finally,

$$f(2)=3(32)-8+4=92.$$

**Step 4:** Conclusion The requested numerical value is $\boxed{92}$.

**Quick Tip to Solve:** Translate a polynomial quotient limit into coefficient conditions before using derivative information.

**26. The number of 7 digits integers formed by using the digits 2, 3, 4, 5 only and having the sum of digits equal to 18 is _____.** [4 marks]

**Solution:**

**Concept:**

- Subtracting the minimum allowed digit converts a fixed digit sum into a nonnegative integer composition.
- Stars and bars counts ordered nonnegative solutions; an upper bound must then be enforced by subtraction.

**Step 1:** Remove the compulsory contribution Write each of the seven digits as $2 + y_i$, where $y_i \in \{0, 1, 2, 3\}$. The minimum digit sum is $7 \cdot 2 = 14$, so the required surplus is

$$y_1 + \cdots + y_7 = 18 - 14 = 4.$$

Each ordered tuple gives exactly one seven-digit integer. There is no leading-zero issue because every original digit is at least 2.

**Step 2:** Count and remove the forbidden tuples Without the upper bounds, the number of nonnegative ordered solutions is

$$\binom{4+7-1}{7-1} = \binom{10}{6} = 210.$$

A forbidden solution has some $y_i \geq 4$. Because the total is only 4, that entry must equal 4 and all six others must equal zero. There are exactly seven such tuples, one for each position. Two entries cannot simultaneously violate the bound, so there is no overlap correction.

**Step 3:** Verify with the possible surplus patterns The permitted partitions of the surplus are $3 + 1$, $2 + 2$, $2 + 1 + 1$, and $1 + 1 + 1 + 1$. They contribute respectively

$$7 \cdot 6 = 42, \quad \binom{7}{2} = 21, \quad 7\binom{6}{2} = 105, \quad \binom{7}{4} = 35.$$

Their sum is $42 + 21 + 105 + 35 = 203$, agreeing with $210 - 7$. Repetition of digits is allowed, so no additional distinctness restriction is imposed.

**Step 4:** Conclusion The number of integers is $\boxed{203}$.

**Quick Tip to Solve:** Subtract the baseline digit first; then check whether stars-and-bars solutions exceed the largest allowed digit.

**27. The remainder when $(556)^{40}$ is divided by 7 is _____.** [4 marks]

**Solution:**

**Concept:**

- If two integers are congruent modulo 7, every positive integer power of them is also congruent modulo 7.
- For a base coprime to the prime 7, Fermat's theorem gives a power cycle dividing 6.

**Step 1:** Reduce the base Dividing 556 by 7 gives

$$556 = 7 \cdot 79 + 3.$$

Thus $556 \equiv 3 \pmod 7$, so it suffices to find the residue of $3^{40}$. Reducing before exponentiation avoids computing the enormous integer $556^{40}$, and it preserves the remainder exactly.

**Step 2:** Find the power cycle The successive residues are

$$3^1 \equiv 3, \quad 3^2 \equiv 2, \quad 3^3 \equiv 6, \quad 3^4 \equiv 4, \quad 3^5 \equiv 5, \quad 3^6 \equiv 1 \pmod 7.$$

Multiplication by another block of $3^6$ therefore does not change a residue. Since $40 = 6 \cdot 6 + 4$, we have

$$3^{40} = (3^6)^6\, 3^4 \equiv 1^6 \cdot 4 = 4 \pmod 7.$$

**Step 3:** Check by repeated squaring An independent short calculation gives $3^2 \equiv 2$, $3^4 \equiv 4$, and $3^8 \equiv 2 \pmod 7$. Hence $3^{16} \equiv 4$ and $3^{32} \equiv 2$. Using $40 = 32 + 8$, $3^{40} \equiv 2 \cdot 2 = 4 \pmod 7$, the same result. A division remainder must lie from 0 to 6 inclusive; 4 already lies in that interval and needs no further adjustment.

**Step 4:** Conclusion The remainder is $\boxed{4}$.

**Quick Tip to Solve:** Reduce both the base and the exponent using a verified power cycle, rather than expanding the original power.

---

**28. Let $[t]$ denote the greatest integer less than or equal to t. Then the value of $10 - 10\int_{-2}^{2} \left[x + x^3\right] dx$ is _____.** [4 marks]

**Solution:**

**Concept:**

- For noninteger $t$, $\lfloor t \rfloor + \lfloor -t \rfloor = -1$. At integers the sum is zero.
- Changing finitely many values of a bounded integrand does not affect its definite integral.

**Step 1:** Pair opposite arguments Put $g(x) = x + x^3$. This is odd: $g(-x) = -g(x)$. Splitting the integral at zero and substituting $x = -u$ in the negative half yields

$$I = \int_0^2 \left(\lfloor g(u) \rfloor + \lfloor -g(u) \rfloor\right) du.$$

The floor of an odd function is generally not odd, so the integral cannot simply be set equal to zero.

**Step 2:** Apply the floor identity correctly If $m < t < m+1$, then $\lfloor t \rfloor = m$ and $\lfloor -t \rfloor = -m-1$, proving that their sum is -1. Here $g\prime(u) = 1 + 3u^2 > 0$, so each integer value of $g(u)$ occurs at most once. Since $g$ ranges from 0 to 10 on $[0, 2]$, there are only finitely many exceptions to the identity. These isolated points have zero contribution to the integral.

**Step 3:** Evaluate the expression Consequently the paired integrand equals -1 except at finitely many points, and

$$I = \int_0^2 (-1)\, du = -2.$$

Substitute this value into the full expression, retaining its two separate factors of 10:

$$10 - 10I = 10 - 10(-2) = 10 + 20 = 30.$$

This also shows why replacing the greatest-integer brackets by ordinary parentheses would give an incorrect result: that replacement loses the constant offset generated by opposite noninteger arguments.

**Step 4:** Conclusion The required value is $\boxed{30}$.

**Quick Tip to Solve:** For the floor of an odd function on a symmetric interval, pair opposite points and use the floor-sum identity.

**29. Let $A = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$. If $k, l \in \mathbb{N}$ be such that $A^k B^l = I$, then the minimum value of $k + l$ is _____.** [4 marks]

**Solution:**

**Concept:**

- The matrix $A$ is a planar rotation through $-\pi/4$; its kth power rotates through $-k\pi/4$.
- Determinants multiply, while $B = \text{diag}(1, -1)$ satisfies $B^2 = I$ and has determinant -1.

**Step 1:** Force the exponent of B to be even Taking determinants in $A^k B^l = I$ gives

$$(\det A)^k (\det B)^l = 1.$$

Directly, $\det A = (1 + 1)/2 = 1$ and $\det B = -1$, so $(-1)^l = 1$. Thus $l$ must be even. For every such $l$, $B^l = I$, reducing the original equation to $A^k = I$. No odd $l$ can be rescued by choosing a different rotation power because its determinant would remain -1.

**Step 2:** Determine the least positive exponent of A The standard rotation matrix has entries $\left[\begin{smallmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{smallmatrix}\right]$. Comparing gives $\theta = -\pi/4$. Hence $A^k = I$ precisely when $-k\pi/4$ is an integer multiple of $2\pi$, or $k$ is a multiple of 8. As a direct check,

$$A^2 = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}, \quad A^4 = -I, \quad A^8 = I.$$

**Step 3:** Minimise under the natural-number constraint Here $k, l \in \mathbb{N}$ are positive integers, so the least permitted pair is $k = 8, l = 2$. Both satisfy the original matrix identity, and every other feasible pair has $k \geq 8$, $l \geq 2$. Therefore $k + l \geq 10$, with equality at the stated pair. Zero exponents are not among these positive natural-number choices.

**Step 4:** Conclusion The minimum is $\boxed{10}$.

**Quick Tip to Solve:** Take determinants first to eliminate impossible parity choices, then use the rotation angle to find the matrix order.

**30.** **Let** $A_1 = [1]$, $A_2 = \begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$, $A_3 = \begin{bmatrix} 6 & 7 & 8 \\ 9 & 10 & 11 \\ 12 & 13 & 14 \end{bmatrix}$, ... **Then the sum of the diagonal elements of** $A_{20}$ **is _____.** [4 marks]

**Solution:**

**Concept:**

- Before the $n \times n$ matrix starts, $1^2 + 2^2 + \cdots + (n-1)^2$ integers have already been used.
- In a row-filled $n \times n$ matrix, successive principal-diagonal positions differ by $n + 1$.

**Step 1:** Find the first entry of A20 The examples fill each matrix row by row with consecutive positive integers, continuing from the previous matrix. The number used before $A_{20}$ is

$$\sum_{r=1}^{19} r^2 = \frac{19 \cdot 20 \cdot 39}{6} = 2470.$$

Thus the upper-left entry, also the first principal-diagonal entry, is $2471$. Starting at 2470 instead would count the last entry of the previous matrix twice.

**Step 2:** Form the diagonal progression Going from position $(i, i)$ to $(i + 1, i + 1)$ advances one complete row, 20 entries, and then one column. Therefore the common difference is 21. The 20 diagonal entries are

$$2471,\ 2492,\ 2513,\ \ldots,\ 2471 + 19 \cdot 21.$$

The last value is $2870$, and the count is 20 rather than 19 because both endpoints belong to the diagonal.

**Step 3:** Sum and cross-check Using the arithmetic-progression sum gives

$$S = \frac{20}{2}(2471 + 2870) = 10 \cdot 5341 = 53410.$$

Equivalently, $S = 20(2471) + 21(0 + 1 + \cdots + 19) = 49420 + 3990$. As a range check, the entire matrix runs from 2471 to $2470 + 400 = 2870$, so its lower-right corner agrees with the final diagonal value. The progression mean is $2670.5$, consistent with a diagonal sum of 20 times that mean.

**Step 4:** Conclusion The sum of the diagonal elements is $\boxed{53410}$.

**Quick Tip to Solve:** Count the entries in all preceding matrices first; the principal diagonal of a row-filled square advances by its size plus one.

**31. Which of the following is not a sustainable development goal targeted to be achieved by 2030?**

[4 marks]

(A) gender equality

(B) zero hunger

(C) good health & well being

(D) space Research

**Correct Answer:** (D) space Research

**Solution:**

**Concept:**

- The United Nations 2030 Agenda has 17 named Sustainable Development Goals covering social, economic and environmental development.
- This is a negative-choice question: three options are official goal titles, and the required answer is the remaining option.

**Step 1:** Identify the named goals Gender Equality is Goal 5. It concerns equal rights and opportunities and the empowerment of women and girls. Zero Hunger is Goal 2 and concerns ending hunger, improving nutrition and promoting food security. Good Health and Well-Being is Goal 3 and concerns healthy lives and well-being for people of all ages. Thus options (A), (B) and (C) each match an explicitly named goal of the 2030 Agenda.

**Step 2:** Distinguish a research activity from a goal title Space research is not one of the 17 Sustainable Development Goal titles. Scientific work and technologies, including satellite observations, may assist development activities, but that does not turn every research field into a separately named SDG. The question asks which item is not itself a goal targeted for achievement under the 2030 Agenda. Accordingly, the presence of useful applications is not a reason to select any of the three actual SDG names.

**Step 3:** Apply the negative wording Because the stem says "not", eliminate the three verified goal titles instead of selecting a familiar development objective. This leaves option (D), Space Research. The distinction is between belonging to the official list and possibly contributing to development; it is the former that the question tests. Goal numbers 2, 3 and 5 provide a direct cross-check for the three rejected choices.

**Step 4:** Conclusion Space Research is not a named Sustainable Development Goal. Hence, the correct option is (D).

**Quick Tip to Solve:** For a NOT question about the SDGs, map the other choices to their official goal numbers before selecting the exception.

**32. KANDARIYA MAHADEV TEMPLE is situated in which state of India?** [4 marks]

(A) Madhya Pradesh

(B) Maharashtra

(C) Rajasthan

(D) Karnataka

**Correct Answer:** (A) Madhya Pradesh

**Solution:**

**Concept:**

- Kandariya Mahadeva Temple belongs to the Khajuraho group of temples, an important example of medieval Indian temple architecture.
- For a monument-location question, identify the town first and then its state; a similar temple style elsewhere does not establish the location.

**Step 1:** Locate the monument The Kandariya Mahadeva Temple is at Khajuraho in Chhatarpur district. Khajuraho is in Madhya Pradesh. The temple is associated with the Chandella period and is a prominent Shiva temple within the Khajuraho group. Its location, rather than a general resemblance to temples in another region, is the decisive fact needed to answer the question.

**Step 2:** Compare all four state choices Option (A), Madhya Pradesh, contains Khajuraho and therefore matches the temple. Maharashtra in option (B) is a different state and does not contain the Khajuraho temple complex. Rajasthan in option (C), although rich in historic temples and forts, is also not the location of Khajuraho. Karnataka in option (D) has major temple centres of its own, but the named Kandariya Mahadeva Temple is not one of those Karnataka monuments.

**Step 3:** Connect the exact name to the correct state The name Kandariya Mahadeva should be linked with the Khajuraho group rather than with a generic reference to a Mahadeva or Shiva temple. Many temples are dedicated to Shiva, so the dedication alone cannot identify the state. Here the particular monument name fixes the place as Khajuraho, making Madhya Pradesh the unique matching option among the four listed choices.

**Step 4:** Conclusion Kandariya Mahadeva Temple is in Madhya Pradesh. Hence, the correct option is (A).

**Quick Tip to Solve:** Remember the chain Kandariya Mahadeva – Khajuraho – Madhya Pradesh to avoid confusing it with other Shiva temples.

**33. Vertical elements in a building are:-** [4 marks]

(A) Column, Lintel, Wall

(B) Lintel, Beam, Arch

(C) Column, Pier, Post

(D) Floor, Column, Arch

**Correct Answer:** (C) Column, Pier, Post

**Solution:**

**Concept:**

- Building elements are classified by their usual orientation and structural role. Vertical members carry loads down towards the foundation.
- A column, pier and post are all upright supporting members; beams and lintels normally span horizontally.

**Step 1:** Identify the common orientation A column is an upright compression member supporting beams or slabs. A pier is a vertical masonry or concrete support, while a post is another upright support, often of timber or steel. Thus all three members in option (C) belong to the vertical category, even though their materials and cross-sections may differ.

**Step 2:** Eliminate the mixed groups Option (A) includes a lintel, which spans over an opening. Option (B) contains a lintel and beam, both horizontal spanning members, together with an arch. Option (D) includes a floor, which is predominantly horizontal. Therefore none of these groups consists entirely of vertical elements.

**Step 3:** Conclusion Column, pier and post are the vertical elements. Hence, the correct option is (C).

**Quick Tip to Solve:** Classify every member in a group; one horizontal element is enough to reject a list of vertical elements.

**34. Cavity Walls are used for** [4 marks]

(A) Waterproofing

(B) Heat Insulation

(C) Aesthetics

(D) Cost saving

**Correct Answer:** (B) Heat Insulation

**Solution:**

**Concept:**

- A cavity wall has two leaves separated by an air space. This interrupts the direct passage of heat through solid masonry.
- Air has low thermal conductivity, so a properly formed cavity improves the thermal insulation of an external wall.

**Step 1:** Connect the cavity with heat transfer In a solid wall, heat is conducted through a continuous

thickness of masonry. In a cavity wall the two leaves are separated, reducing that continuous conductive path. The air space, or insulation placed within it, limits heat flow between the outdoor and indoor environments and helps moderate indoor temperatures.

**Step 2:** Compare the proposed purposes Heat insulation is the intended building-performance answer. A cavity can also help prevent rain penetration when properly detailed, but it is not a waterproofing treatment by itself. Aesthetics depends mainly on the exposed finish, not the hidden air gap. Two leaves and their ties are not installed primarily to save construction cost.

**Step 3:** Conclusion Cavity walls are used for heat insulation. Hence, the correct option is (B).

**Quick Tip to Solve:** For an air-gap construction question, first look for reduced heat transfer rather than appearance or price.

**35. Lintel is related to:** [4 marks]

(A) Window

(B) Roof

(C) Foundation

(D) Pipe

**Correct Answer:** (A) Window

**Solution:**

**Concept:**

- A lintel is a horizontal structural member placed over an opening in a wall, such as a door or window.
- It carries masonry and other loads above the opening to the wall or supports at either side, avoiding loading the window frame directly.

**Step 1:** Locate the lintel in a wall A window interrupts the continuity of a masonry wall. The masonry above that opening requires support across its width. A lintel spans between the jambs above the window and transfers the supported load to the adjacent wall. This is why a window is directly associated with a lintel.

**Step 2:** Distinguish the other building parts A roof is the upper covering of a building and can be supported by walls, beams or trusses. A foundation transfers building loads into the ground. A pipe conveys fluid or houses services. None of these is the opening over which a lintel is characteristically provided; the window is the relevant listed element.

**Step 3:** Conclusion A lintel is related to a window. Hence, the correct option is (A).

**Quick Tip to Solve:** Remember lintel level as the horizontal level immediately above door and window openings.

**36. Choose the correct option among the following by looking at the image given above:** [4 marks]



(A) Lodhi Garden

(B) Jantar Mantar

(C) Rajghat

(D) Bahai Temple

**Correct Answer:** (B) Jantar Mantar

**Solution:**

**Concept:**

- Astronomical observatories such as Jantar Mantar use large fixed masonry instruments, including curved and inclined surfaces.
- Identify a monument by its distinctive built form rather than by the surrounding trees or modern buildings.

**Step 1:** Read the visible instrument The photograph shows an open masonry instrument with curved, nearly circular walls and an inclined central element. These geometric surfaces are characteristic of the large astronomical instruments at Jantar Mantar. The structure is an observing instrument rather than an enclosed worship space or a commemorative platform.

**Step 2:** Exclude the other monuments Lodhi Garden is associated with garden tombs and their domes. Rajghat is identified by its simple black memorial platform, not by a circular astronomical instrument. The Bahai Temple has the prominent lotus-petal shell form, which is absent here. The instrument geometry therefore selects Jantar Mantar from the four names.

**Step 3:** Conclusion The image shows Jantar Mantar. Hence, the correct option is (B).

**Quick Tip to Solve:** Large geometric masonry instruments point to Jantar Mantar; lotus-shaped white shells point to the Bahai Temple.

**37. ARCHITECT ACT 1972 was enforced in which month** [4 marks]

(A) 31st Dec

(B) 31st May

(C) 31st July

(D) 31st March

**Correct Answer:** No listed option gives the literal enforcement date, 1 September 1972. The supplied key intends (B), 31 May 1972, the enactment date.

**Solution:**

**Concept:**

- The Architects Act, 1972 is the Indian legislation concerned with registration of architects and the Council of Architecture.
- The Act bears the date 31 May 1972. The date of enactment must be distinguished from the commencement of particular provisions.

**Step 1:** Identify the date represented by the options The date associated with enactment of the Architects Act, 1972 is 31 May 1972. All four choices give the thirty-first day, so the distinguishing information being tested in this question is the month. Matching the Act date gives May, which is option (B).

**Step 2:** Handle the wording precisely The word "enforced" is imprecise here: enactment and commencement are distinct legal events, and the Act came into force on 1 September 1972. That commencement date is not among the choices. Within the supplied options, the intended answer is 31 May, the enactment date; 31 December, 31 July and 31 March do not give that Act date.

**Step 3:** Conclusion No listed date is the literal enforcement date: the Act commenced on 1 September 1972. The supplied answer key intends option (B), 31 May 1972, which is its enactment date.

**Quick Tip to Solve:** Keep the Act date, 31 May 1972, separate from commencement on 1 September 1972 when reading questions about legislation.

**38. The dome of Rashtrapati Bhawan is influenced by which of the following:** [4 marks]

(A) Gurudwara

(B) Mosque

(C) Stupa

(D) Temple

**Correct Answer:** (C) Stupa

**Solution:**

**Concept:**

- Rashtrapati Bhavan combines classical architectural composition with Indian architectural references.
- The principal dome is associated with the Buddhist stupa tradition, particularly the Great Stupa at

Sanchi.

**Step 1:** Recognise the architectural reference The monumental central dome of Rashtrapati Bhavan is commonly linked to the form of the Sanchi Stupa. Its broad rounded mass and the Indian railing-like treatment around its base recall the stupa vocabulary. The question asks for the type of structure influencing the dome, rather than the building's present administrative use.

**Step 2:** Choose the specific category A stupa is the Buddhist commemorative structure represented by the Sanchi example, so option (C) gives the required category. Gurudwaras, mosques and temples can also possess domes or elevated roof forms, but none names the particular stupa reference asked for here. The mere presence of a dome does not make a mosque the correct influence.

**Step 3:** Conclusion The dome is influenced by a stupa. Hence, the correct option is (C).

**Quick Tip to Solve:** Link Rashtrapati Bhavan's central dome with Sanchi, then identify Sanchi's structural type as a stupa.

**39. Dominion tower is designed by** [4 marks]

(A) Bjarke Ingels

(B) Zaha Hadid

(C) Frei otto

(D) F.L. Wright

**Correct Answer:** (B) Zaha Hadid

**Solution:**

**Concept:**

- Architectural-awareness questions match a named building with its designer; a building's shape alone is not sufficient identification.
- Dominion Tower in Moscow is a project of Zaha Hadid Architects and is associated with Zaha Hadid.

**Step 1:** Recall the project-designer pair Dominion Tower is the Moscow office building associated with Zaha Hadid. Its composition includes shifted horizontal layers and a dramatic internal circulation space, consistent with the spatial experimentation of her practice. Thus the named designer among the choices is Zaha Hadid.

**Step 2:** Eliminate the alternative architects Bjarke Ingels is associated with BIG and projects such as 8 House. Frei Otto is particularly known for lightweight tensile and membrane structures, including the Munich Olympic roof. Frank Lloyd Wright is associated with works such as Fallingwater and the Guggenheim Museum in New York. These are different project-designer associations and do not identify Dominion Tower.

**Step 3:** Conclusion Dominion Tower was designed by Zaha Hadid. Hence, the correct option is (B).

**Quick Tip to Solve:** Learn a small set of distinctive building-designer pairs: Dominion Tower belongs with Zaha Hadid.

**40. The largest river island of the world is present in which state of India?** [4 marks]

(A) Maharastra

(B) Assam

(C) Uttar Pradesh

(D) West Bengal

**Correct Answer:** (B) Assam

**Solution:**

**Concept:**

- Majuli is the well-known large river island in the Brahmaputra river system and is located in Assam.
- The question asks for the Indian state, so the geographical chain is island, river, then state.

**Step 1:** Identify the island and river The river island referred to in this standard geography question is Majuli. It lies in the Brahmaputra in northeastern India. Its area changes because of erosion and deposition, but its geographical location is in Assam; the state answer does not require a current measurement of its area.

**Step 2:** Match the state to the choices Assam is option (B) and is the state through which the Brahmaputra flows across the valley containing Majuli. Maharashtra is in western India, Uttar Pradesh lies principally in the Ganga plain, and West Bengal lies farther downstream in the Ganga-Brahmaputra regional system. None of those three states contains Majuli.

**Step 3:** Conclusion The island is Majuli in Assam. Hence, the correct option is (B).

**Quick Tip to Solve:** Use the association Majuli–Brahmaputra–Assam to retrieve the island, river and state together.

**41. Who prepared the first layout of the town of Jamshedpur?** [4 marks]

(A) Charles Correa

(B) Otto Konigsberger

(C) Le Corbuseir

(D) Messrs Julin Kennedy Sahhin

**Correct Answer:** (D) Messrs Julin Kennedy Sahhin

**Solution:**

**Concept:**

- Town-planning attribution must distinguish the first layout from a later extension or redevelopment plan. The word first is decisive in this question.
- Jamshedpur developed around the Tata steel works. Its original industrial township layout is associated with Messrs Julian Kennedy Sahlin, represented by the spelling in option (D).

**Step 1:** Identify the original planning commission The early layout provided the spatial framework for the steel township: the relationship of the works to residential areas, roads and supporting facilities. The firm associated with this initial stage was Messrs Julian Kennedy Sahlin. Thus the question asks

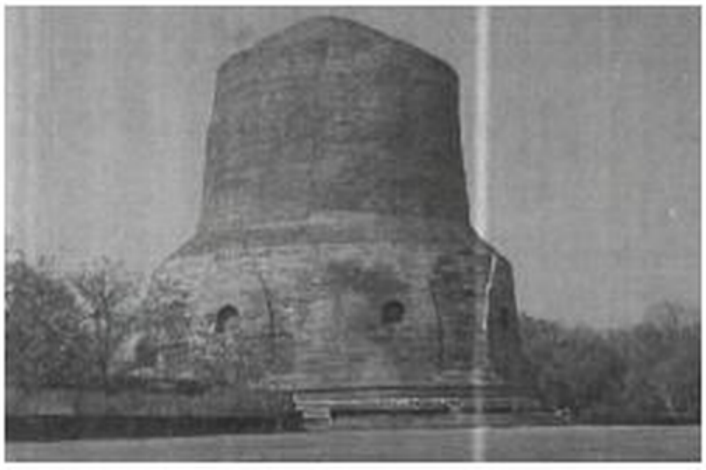
for an early planning attribution, rather than the most famous architect in the list.

**Step 2:** Separate the original plan from later work Otto Konigsberger is associated with a later planning phase of Jamshedpur, so his connection with the city does not make him the author of its first layout. Charles Correa belongs to a later generation of Indian architecture and planning. Le Corbusier is strongly associated with the planning and architecture of Chandigarh; that association does not answer the present question. Therefore options (A), (B) and (C) do not satisfy the particular historical stage requested.

**Step 3:** Conclusion The first layout of Jamshedpur was prepared by Messrs Julian Kennedy Sahlin, corresponding to the name printed in option (D). Hence, the correct option is (D).

**Quick Tip to Solve:** For town-planning questions, attach the planner to the particular phase: original layout, later master plan or subsequent expansion.

**42. Identify the historical monument which is given in the image.** [4 marks]



(A) Sanchi Stupa

(B) Victory Tower

(C) Sarnath Stupa

(D) Nalanda

**Correct Answer:** (C) Sarnath Stupa

**Solution:**

**Concept:**

- A monument can be identified from its overall mass, profile, material and surviving architectural features. Match the dominant form before relying on small surface details.
- The Dhamek Stupa at Sarnath has a massive cylindrical drum on a broad base. Its form differs from the hemispherical Great Stupa at Sanchi.

**Step 1:** Read the form visible in the photograph The photograph shows a substantial, nearly cylindrical solid monument. Its broad lower portion and tall upper drum create a heavy circular mass, rather

than the open rooms of a monastery or the narrow vertical silhouette of a tower. These visible features identify the Dhamek Stupa, which is situated at Sarnath.

**Step 2:** Eliminate the other monument types Sanchi Stupa is principally recognised by its hemispherical dome and its surrounding railings and gateways; that is not the profile shown. The Victory Tower is a tall, slender, multi-storeyed tower, whereas the photographed structure is broad and drum-shaped. Nalanda is recognised as a monastic and educational complex with brick buildings and ruins; its name does not identify this particular massive cylindrical stupa. Option (C), Sarnath Stupa, is the description that matches the image as a whole.

**Step 3:** Conclusion The monument shown is the Dhamek Stupa at Sarnath. Hence, the correct option is (C).

**Quick Tip to Solve:** Use the silhouette first: a hemispherical dome suggests Sanchi, while a massive cylindrical drum is characteristic of the Dhamek Stupa at Sarnath.

**43. Who was known as "Father of modern concrete"?** [4 marks]

(A) John Paul

(B) John Nash

(C) John Smeaton

(D) Joseph Stein

**Correct Answer:** (C) John Smeaton

**Solution:**

**Concept:**

- The development of modern concrete depended on binders that could set and remain effective in wet conditions. Hydraulic lime was an important stage in that development.
- John Smeaton investigated hydraulic lime and used it in the construction of the Eddystone Lighthouse. This contribution explains the historical title asked for here.

**Step 1:** Connect the title with the material advance John Smeaton studied how the composition of limestone affected the properties of the lime produced from it. Lime containing suitable clay constituents could develop hydraulic properties, allowing the binder to set under water. This was particularly valuable for lighthouse foundations exposed to the sea and contributed to the development of modern concrete construction.

**Step 2:** Compare the names offered The person associated with this pioneering work on hydraulic lime and concrete is John Smeaton, option (C). John Nash is known as an architect, particularly for buildings and urban work, rather than for this experimental contribution to concrete. Joseph Stein is associated with modern architectural design in India, not the early development of hydraulic concrete. John Paul is not the historical figure linked to the stated material innovation. The title therefore identifies a specific engineering contribution, not merely a designer who used concrete.

**Step 3:** Conclusion John Smeaton is the person referred to as the Father of modern concrete. Hence, the correct option is (C).

**Quick Tip to Solve:** Link Smeaton with hydraulic lime and the Eddystone Lighthouse; that material-and-project pair distinguishes him from later concrete architects.

**44. Who is the architect of TWA Airport, New York?** [4 marks]

(A) Eero Saarinen

(B) Mies Vander Rohe

(C) Joseph Allen Stein

(D) Alvar Aalto

**Correct Answer:** (A) Eero Saarinen

**Solution:**

**Concept:**

- Landmark-building questions require the architect of the specific building, rather than the designer of the entire city or airport infrastructure.
- The TWA Flight Center in New York is associated with Eero Saarinen and is recognised for its expressive, sweeping concrete forms.

**Step 1:** Identify the building meant by the question The reference to the TWA Airport is to the celebrated TWA Flight Center at New York's John F. Kennedy International Airport. The terminal was designed by Eero Saarinen. Its sculptural roof and flowing spaces make it an important example of an airport terminal conceived as an expressive architectural composition.

**Step 2:** Distinguish the other architects Mies van der Rohe is associated with a restrained language of steel, glass and clearly expressed structural frames; he is not the architect of the TWA Flight Center. Joseph Allen Stein is especially associated with modern architecture in India and did not design this terminal. Alvar Aalto is a Finnish modernist known for his own buildings and human-centred design approach, but the TWA commission belongs to Saarinen. Recognising the particular architect-building pair eliminates options (B), (C) and (D), regardless of the wider reputations of those architects.

**Step 3:** Conclusion Eero Saarinen designed the TWA Flight Center in New York. Hence, the correct option is (A).

**Quick Tip to Solve:** Remember TWA Flight Center together with Eero Saarinen and its sweeping roof; do not confuse Saarinen with the other Finnish architect Alvar Aalto.

**45. Starting from a point, Maria walked 12 meters towards North, she turned right and walked 10 meters. She again turned right and walked 12 meters, then she turned left and walked 5 meters. How far is she now and in which direction from the starting point? Consider the starting point is in south direction.** [4 marks]

(A) 27 meters towards East

(B) 5 meters towards East

(C) 10 meters towards West

(D) 15 meters towards East

**Correct Answer:** (D) 15 meters towards East

**Solution:**

**Concept:**

- Displacement is the change from the starting position to the final position. It is different from the total length of the route walked.
- Right and left turns are relative to the direction currently faced. Take east as the positive horizontal direction and north as the positive vertical direction.

**Step 1:** Follow each turn in the current direction Start at $(0, 0)$. Walking north for 12 metres brings Maria to $(0, 12)$. A right turn from north points east, so the next 10 metres takes her to $(10, 12)$. A second right turn, now from east, points south. Walking 12 metres south returns her to the original north–south level, at $(10, 0)$.

**Step 2:** Find the final displacement and compare options Maria is facing south at this stage. A left turn from south points east, so the last 5 metres brings her to $(15, 0)$. The north and south movements cancel exactly, while both horizontal movements are eastward. Thus the displacement is

$$(10 + 5)\,\mathrm{m} = 15\,\mathrm{m} \quad \text{east.}$$

Option (A) adds an incorrect distance, option (B) counts only the final leg, and option (C) gives the wrong direction and omits the final eastward movement. The initial point being south of the first northward point is consistent with this coordinate description.

**Step 3:** Conclusion Maria is $15\,\mathrm{m}$ east of the starting point. Hence, the correct option is (D).

**Quick Tip to Solve:** Cancel equal north and south legs, then add the eastward legs; determine each turn from the direction faced immediately before it.

**46. Who among the following is not Pritzker prize winner?** [4 marks]

(A) Wang Shu

(B) B.V. Doshi

(C) Arata Isozaki

(D) Denise Scott Brown

**Correct Answer:** (D) Denise Scott Brown

**Solution:**

**Concept:**

- The Pritzker Architecture Prize is awarded to named laureates. Association with a winning architect does not automatically confer laureate status.
- For this question, compare the named individuals with the winners already recognised by the date of the paper in April 2023.

**Step 1:** Identify the three recorded laureates Wang Shu received the Pritzker Architecture Prize in 2012. Balkrishna Vithaldas Doshi, named as B.V. Doshi in the options, received it in 2018. Arata Isozaki received it in 2019. Therefore each of options (A), (B) and (C) names an actual Pritzker laureate and must be excluded when the question asks who is not a winner.

**Step 2:** Distinguish professional collaboration from the award Denise Scott Brown is a prominent architect, planner and theorist. However, she was not a Pritzker laureate at the time of this paper. Her architectural partnership with Robert Venturi should not be confused with the formal naming of the recipient: the 1991 Pritzker Prize was awarded to Venturi. The question is about receipt of this particular prize, rather than importance to architectural history, other honours, or participation in the work of a practice. With the other three names positively matched to their award years, Denise Scott Brown is the remaining and correct choice.

**Step 3:** Conclusion Denise Scott Brown was not a Pritzker Architecture Prize winner at the time of the examination. Hence, the correct option is (D).

**Quick Tip to Solve:** For award questions, recall the named recipient and year; a collaborator or partner of a laureate is not automatically a laureate.

**47. Which of the following is not Antonio Gaudi's project?** [4 marks]

(A) Casa Mila

(B) Sagrada Familia

(C) Casa Batllo

(D) Casa Milano

**Correct Answer:** (D) Casa Milano

**Solution:**

**Concept:**

- Identify an architect's projects by matching exact building names. Similar names beginning with Casa do not necessarily refer to the same architect.
- Casa Mila, Casa Batllo and the Sagrada Familia are recognised works of Antoni Gaudi in Barcelona.

**Step 1:** Verify the three established Gaudi works Casa Mila, also known as La Pedrera, is an apartment building associated with Gaudi and is recognised for its undulating exterior. Casa Batllo is another celebrated Barcelona building transformed by Gaudi, with an expressive facade and distinctive roof. The Sagrada Familia is the basilica whose design and long construction history are closely associated with him. Thus options (A), (B) and (C) are all genuine Gaudi project names.

**Step 2:** Select the name outside that group Casa Milano is not one of the Gaudi projects identified by the other three options. The word Casa is simply a term used in building names and does not establish authorship. In particular, Casa Mila and Casa Milano must not be treated as alternative spellings of the same answer: the former is the well-known Gaudi building in Barcelona, while the latter is the distractor in this list. Since the question asks for the project that is not his, the correct procedure is to retain the three positively identified works and select the remaining name, rather than choosing the most familiar building.

**Step 3:** Conclusion Casa Milano is not a project of Antoni Gaudi among the names listed. Hence, the correct option is (D).

**Quick Tip to Solve:** Group Casa Mila, Casa Batllo and Sagrada Familia as Gaudi landmarks; read Mila carefully so that a similar-looking name does not mislead you.

**48. Which one of the following is most earthquake resistant structure?** [4 marks]

(A) RCC framed structure

(B) Load bearing structure

(C) Mud walls structure

(D) Random stone masonary structure

**Correct Answer:** (A) RCC framed structure

**Solution:**

**Concept:**

- Earthquake resistance depends on the ability of a structural system to carry lateral forces, maintain a continuous load path and accommodate deformation without brittle collapse.
- A properly designed and detailed reinforced cement concrete frame combines concrete's compressive capacity with steel reinforcement and ductile frame action.

**Step 1:** Compare the way the systems resist shaking In an RCC framed structure, interconnected beams and columns form a load-resisting skeleton. When the members, joints, reinforcement and foundations are properly designed and detailed, the frame can resist seismic forces and accommodate cyclic lateral displacement. Steel reinforcement helps the members retain integrity after concrete cracks, and suitable ductile detailing allows energy to be dissipated rather than producing an immediate brittle failure.

**Step 2:** Eliminate the weaker general alternatives Ordinary load-bearing masonry relies heavily on walls and may fail in a brittle manner unless specifically reinforced and tied for seismic action. Mud walls generally have poor tensile resistance and can lose stability during shaking. Random stone masonry has irregular units and, without appropriate bonds and reinforcement, weak connections that are vulnerable to separation and collapse. These descriptions do not imply that every RCC building is safe: poor design or workmanship can make it vulnerable too. Among the broad structural types offered, however, a properly engineered RCC frame provides the most favourable earthquake-resistant system, so options (B), (C) and (D) are not the best answer.

**Step 3:** Conclusion A properly designed and detailed RCC framed structure is the most earthquake-resistant of the systems listed. Hence, the correct option is (A).

**Quick Tip to Solve:** Choose the system with a continuous lateral load path and ductile connections; material strength alone does not establish earthquake safety.

**49. "CHALK" belongs to which category?** [4 marks]

(A) Rock

(B) Mineral

(C) Wood

(D) Polymer

**Correct Answer:** (A) Rock

**Solution:**

**Concept:**

- Rocks are naturally occurring geological materials composed of one or more minerals. A mineral is identified as a particular naturally occurring substance with a characteristic composition and crystal structure.
- Chalk is a soft, white, fine-grained sedimentary limestone. Its main constituent is calcium carbonate, commonly present as the mineral calcite.

**Step 1:** Identify the geological material Chalk forms from the accumulation of very small calcareous remains of marine organisms. This biological origin and subsequent accumulation of sediment place chalk among sedimentary rocks. Its softness and white appearance are useful identifying features, but they do not change its classification.

**Step 2:** Distinguish the options Option (A), rock, is the appropriate category for the material chalk. Option (B), mineral, confuses the whole rock with its principal mineral constituent, calcite. Option (C), wood, is a plant-derived structural material with a fibrous cellular structure, unlike chalk. Option (D), polymer, describes substances built from repeating molecular units and is not the geological classification of chalk. A material can contain a mineral without itself being classified as that individual mineral.

**Step 3:** Conclusion Chalk is a sedimentary rock, specifically a form of limestone. Hence, the correct option is (A).

**Quick Tip to Solve:** Distinguish a rock from its constituent mineral: chalk is the rock, whereas calcite is its principal mineral.

**50. What are the three parts of colour theory?** [4 marks]

(A) hyper, value and chrome

(B) honey, violet and chroma

(C) hue, value and chroma

(D) hue, chrome and violet

**Correct Answer:** (C) hue, value and chroma

**Solution:**

**Concept:**

- The three standard attributes used to describe a colour are hue, value and chroma. Each attribute answers a different question about the observed colour.

- Hue identifies the colour family, value describes lightness or darkness, and chroma describes the strength or saturation of the colour.

**Step 1:** Recall the three attributes Hue tells us whether a colour is perceived as red, yellow, blue or another colour family. Value places that colour on a light-to-dark scale. Chroma distinguishes a strong, vivid version of a hue from a dull, muted version. For example, two samples may have the same hue but differ in either lightness or saturation; describing only their colour names would not distinguish them adequately.

**Step 2:** Compare the listed groups Option (C) contains the exact set hue, value and chroma, so it supplies all three attributes. Option (A) uses hyper and chrome instead of the accepted names hue and chroma. Option (B) uses honey and violet, which are not a set of three colour attributes. Option (D) includes violet, a particular hue, and chrome rather than chroma, while omitting value. A particular colour name cannot replace an attribute used to describe every colour.

**Step 3:** Conclusion The three attributes are hue, value and chroma. Hence, the correct option is (C).

**Quick Tip to Solve:** Remember three separate questions: which hue, how light or dark, and how vivid or dull?

**51. Identify the three primary colours?** [4 marks]

(A) Red, Blue and Green

(B) Red, Yellow and Blue

(C) Black, White and Yellow

(D) Blue, White and Yellow

**Correct Answer:** (B) Red, Yellow and Blue

**Solution:**

**Concept:**

- In the traditional pigment or artist colour system used for basic colour theory, the primary colours are red, yellow and blue.
- The primary set depends on the colour-mixing system. Red, green and blue are additive primaries for light; they are not the traditional painting primaries.

**Step 1:** Identify the colour system The question occurs in the context of visual art and design colour theory. In the traditional red-yellow-blue colour wheel, red, yellow and blue form the primary triad. Their mixtures produce the familiar secondary colours: red with yellow gives orange, yellow with blue gives green, and blue with red gives violet. These relationships identify the set asked for here.

**Step 2:** Eliminate the competing sets Option (B) lists red, yellow and blue and is therefore the intended pigment-system answer. Option (A), red, blue and green, is the additive set used for light, such as in screens; it belongs to a different mixing system. Options (C) and (D) include white, and option (C) also includes black. Black and white are used to alter value and are not members of the traditional three chromatic primaries. Thus neither set can generate the traditional colour-wheel relationships stated above.

**Step 3:** Conclusion For the traditional artist colour system, the primary colours are red, yellow and

blue. Hence, the correct option is (B).

**Quick Tip to Solve:** Check the mixing medium first: traditional painting uses RYB, while emitted light uses RGB.

**52. Match List I with List II:**

| List I | List II |
|---|---|
| A. Kamakhya Temple | I. Madhya Pradesh |
| B. Padmanabha Temple | II. Rajasthan |
| C. Kandariya Mahadev | III. Assam |
| D. Karni Mata Temple | IV. Kerala |

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

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

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

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

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

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

**Solution:**

**Concept:**

- A temple-location matching question is solved by identifying the state of each named monument and then translating it into the corresponding Roman numeral.
- The states in List II are I: Madhya Pradesh, II: Rajasthan, III: Assam and IV: Kerala. The letters refer to the monuments, not to the answer options.

**Step 1:** Locate each temple Kamakhya Temple is at Guwahati in Assam, so A matches III. Padmanabha Temple, the Sree Padmanabhaswamy Temple, is at Thiruvananthapuram in Kerala, so B matches IV. Kandariya Mahadev Temple belongs to the Khajuraho group in Madhya Pradesh, so C matches I. Karni Mata Temple at Deshnoke, near Bikaner, is in Rajasthan, so D matches II. These four place-state associations determine every entry independently.

**Step 2:** Select the complete matching code Combining the four results gives A-III, B-IV, C-I, D-II. This is exactly option (C). Option (A) incorrectly places Kamakhya in Rajasthan and Padmanabha in Madhya Pradesh. Option (B) incorrectly puts Kamakhya in Kerala and Kandariya Mahadev in Rajasthan. Option (D) incorrectly places Kamakhya in Madhya Pradesh and Karni Mata in Assam. A complete matching code must agree with all four monuments, not merely with one familiar entry.

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

**Quick Tip to Solve:** Use one certain temple-state pair to shortlist the codes, then verify every remaining pair before selecting.

**53. A square has an area of 100 sq.mt. How much will be its area on a scale of 1 : 20?** [4 marks]

(A) 5 sq.mt.

(B) 50 sq.mt.

(C) 0.25 sq.mt.

(D) 25 sq.mt.

**Correct Answer:** (C) 0.25 sq.mt.

**Solution:**

**Concept:**

- A scale of 1:20 means that every length in the scaled drawing is one twentieth of the corresponding actual length, provided both lengths use the same unit.
- Area depends on two perpendicular lengths. Consequently, an area is multiplied by the square of the linear scale factor: $A_{\text{scaled}} = A_{\text{actual}}(1/20)^2$.

**Step 1:** Find the scaled side The actual square has area $100\,\text{m}^2$, so its side is the positive square root of its area. Thus

$$s = \sqrt{100} = 10\,\text{m}.$$

Applying the linear reduction gives

$$s_{\text{scaled}} = \frac{10}{20} = 0.5\,\text{m}.$$

The scale acts on the side length, not directly on the numerical value of the area.

**Step 2:** Calculate and check the area The scaled square therefore has area

$$A_{\text{scaled}} = (0.5)^2 = 0.25\,\text{m}^2.$$

Equivalently, $100/20^2 = 100/400 = 0.25$. Option (C) is the resulting area. Option (A), 5, comes from dividing the original area by 20 only once and fails to account for the reduction in both dimensions. Options (B), 50, and (D), 25, likewise do not apply the squared scale factor. As a check, the area must be 400 times smaller while the side is 20 times smaller.

**Step 3:** Conclusion The area on a scale of 1:20 is $0.25\,\text{m}^2$. Hence, the correct option is (C).

**Quick Tip to Solve:** For a drawing scale 1:n, divide lengths by n, areas by n squared and volumes by n cubed.

**54. Given below are two statements:**

**Statement I: Shakti Sthal is a memorial in Raj Ghat marking the cremation site of Indira Gandhi.**

**Statement II: A.P. Kanvinde in the landscape designer known for designing Shakti Sthal.**

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

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

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

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

**Solution:**

**Concept:**

- A two-statement factual question requires a separate truth assessment of each statement before the combined option is chosen.
- Shakti Sthal is the memorial associated with Indira Gandhi, while its landscape design is associated with Ravindra Bhan. The identity of the person commemorated and the designer are distinct facts.

**Step 1:** Evaluate Statement I Shakti Sthal marks the cremation site of Indira Gandhi in the Raj Ghat memorial area of New Delhi. The statement correctly associates the memorial, the person commemorated and the memorial precinct. Therefore Statement I is true. The reference to Raj Ghat identifies the wider memorial area; it does not mean that the memorial to Mahatma Gandhi and Shakti Sthal are the same monument.

**Step 2:** Evaluate Statement II and choose The landscape designer associated with Shakti Sthal is Ravindra Bhan, not A. P. Kanvinde. Thus Statement II is false. Kanvinde is an important Indian architect, but recognising a prominent name is not sufficient to establish the attribution in the statement. Option (A) fails because it treats Statement II as true. Option (B) fails because Statement I is true. Option (D) reverses both truth values. Only option (C) combines the independently obtained results: true for Statement I and false for Statement II.

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

**Quick Tip to Solve:** Separate memorial identification from designer attribution; a correct association in one statement does not validate the other.

**55. What is the full form of 'UDAY'?** [4 marks]

(A) Ujjwala Discom Assitance Yojana

(B) Unnati Development Ayojan Yojana

(C) Ujwal Distribution Assurance Yojana

(D) Ujwal Discom Assurance Yojana

**Correct Answer:** (D) Ujwal Discom Assurance Yojana

**Solution:**

**Concept:**

- UDAY is the abbreviation for Ujwal DISCOM Assurance Yojana. DISCOM is the commonly used abbreviation for an electricity distribution company.
- An acronym question requires the official scheme name, rather than a phrase that merely expands to similar initial letters or describes a related policy purpose.

**Step 1:** Recall the complete scheme name The name is Ujwal Discom Assurance Yojana. The scheme concerns the financial and operational turnaround of power distribution companies, which explains why DISCOM is retained in its title. Reading the phrase as a whole is helpful: Ujwal is followed by Discom, Assurance and Yojana. It is not the Ujjwala scheme, and the word Assurance must not be replaced by Assistance.

**Step 2:** Check each alternative precisely Option (D) reproduces Ujwal Discom Assurance Yojana and therefore matches the name. Option (A) uses Ujjwala and Assistance, which are not the required words. Option (B), Unnati Development Ayojan Yojana, is a different invented expansion of the initials and does not name UDAY. Option (C) substitutes Distribution for Discom. Although DISCOM itself refers to a distribution company, expanding or replacing a word inside an official title does not give the exact full form asked for. Hence the wording in (D), rather than its approximate paraphrase, is decisive.

**Step 3:** Conclusion UDAY stands for Ujwal Discom Assurance Yojana. Hence, the correct option is (D).

**Quick Tip to Solve:** For scheme acronyms, compare every official word; similar initials and a plausible policy description are insufficient.

**56. What is the acronym for 'AYUSH'?** [4 marks]

(A) Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy

(B) Ayurveda, Yogic and Unani Siddha and Homeopathy

(C) Acroveda, Yoga, Unani, Siddha and Homeopathy

(D) Ayurveda, Yoga, Naturopathy, Unani Surgery and Homeopathy

**Correct Answer:** (A) Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy

**Solution:**

**Concept:**

- AYUSH is the collective abbreviation for Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy.
- Yoga and Naturopathy are grouped together in the expansion. The final two letters identify Siddha and Homoeopathy; they do not stand for surgery.

**Step 1:** Expand the abbreviation in order Read the recognised systems in sequence: A refers to Ayurveda; Y represents Yoga and Naturopathy as the grouped component; U refers to Unani; S refers to Siddha; and H refers to Homoeopathy. The list concerns established systems of healthcare rather than a collection of generic treatment procedures. Keeping the complete grouped expression Yoga and Naturopathy avoids accidentally omitting one of its components.

**Step 2:** Compare all four printed lists Option (A) includes Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy, matching the recognised expansion; Homeopathy is the spelling used in the option for Homoeopathy. Option (B) uses Yogic and omits Naturopathy, so it does not give the complete name. Option (C) starts with Acroveda instead of Ayurveda and also fails to include the complete grouped component. Option (D) replaces Siddha with Surgery and separates the terms incorrectly. Surgery is a procedure, whereas Siddha is the named system represented by S. Only option (A) preserves all the required systems.

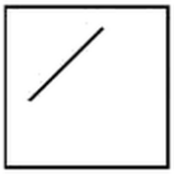
**Step 3:** Conclusion AYUSH stands for Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy. Hence, the correct option is (A).

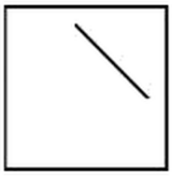
**Quick Tip to Solve:** Remember the grouped middle expression Yoga and Naturopathy, and keep Siddha as S rather than substituting Surgery.

**57. Select the correct option from answer figure which will be best suitable to continue the same pattern as established by the problem figure.** [4 marks]

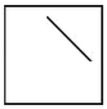



(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (C) 

**Solution:**

**Concept:**

- A figure series can change by deleting one component at each stage while leaving the other components fixed.
- The diamond consists of four oblique sides. Follow the missing sides around its perimeter rather than treating each remaining shape as a new rotated object.

**Step 1:** Compare the first three figures The first figure is a complete diamond. In the second figure its lower-right side is missing, leaving three sides. The third figure has also lost the lower-left side, so only the two upper sides remain. Thus the number of sides decreases successively from four to three to two. Neither the size nor the position of the retained sides changes.

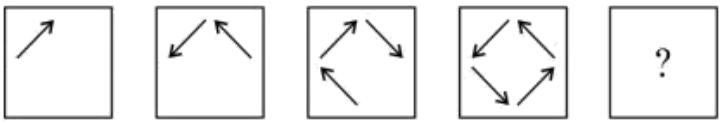
**Step 2:** Continue the deletion around the diamond The deletions proceed around the diamond: lower-right, lower-left, and then upper-left. Removing that third side leaves only the upper-right side, a line descending from left to right. This is the oblique stroke in option (C). The square surrounding an answer figure is only its enclosing frame; it is not an additional side of the evolving diamond.

**Step 3:** Eliminate the other answer figures Option (A) contains two lower sides and reverses the deletion process. Option (B) leaves the upper-left side, which would require skipping the next side in the established order. Option (D) retains both upper sides and simply repeats the third figure. Only option (C) both reduces the count to one and preserves the next surviving side.

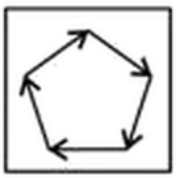
**Step 4:** Conclusion Only the upper-right side remains. Hence, the correct option is (C).

**Quick Tip to Solve:** Number the diamond sides clockwise, then cross out one side at each stage to track both count and position.

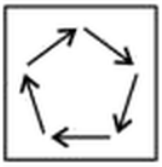
**58. Choose the correct option from the answer figures which completes the question series.** [4 marks]

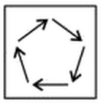



(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (D) 

**Solution:**

**Concept:**

- A non-verbal sequence may change both the number of components and their direction. These rules must be checked together.
- Here each new figure adds one arrow, and the arrows alternately circulate clockwise and anticlockwise around a developing polygon.

**Step 1:** Count the arrows and compare their directions The four given figures contain one, two, three and four arrows respectively. The missing figure must therefore contain five arrows. The first and third figures follow the clockwise sense, while the second and fourth follow the opposite sense. Consequently the fifth figure must return to the clockwise sense rather than merely add another arrow to the fourth orientation.

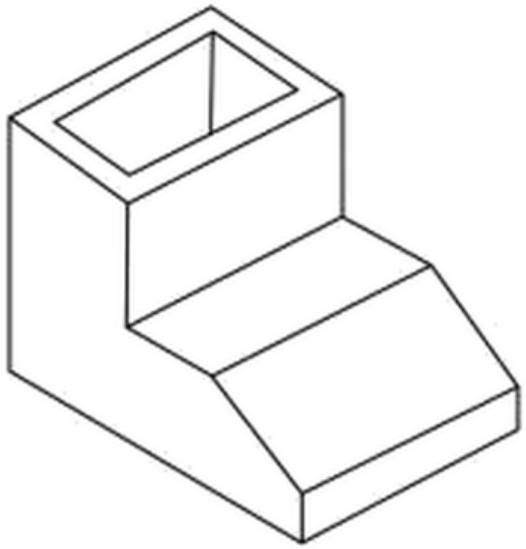
**Step 2:** Preserve the form of each arrow The arrows are separate strokes placed around the boundary; the arrowhead terminates an individual stroke, with a gap before the next stroke. Five such arrows form the sides of a pentagonal arrangement. Starting near the upper-left and moving clockwise, their directions are up-right, down-right, down-left, left and up-left. Option (D) supplies this arrangement with the individual strokes kept separate.

**Step 3:** Compare all four alternatives Option (A) circulates in the reverse sense. Option (C) is a plain pentagon with no arrowheads, so it fails the direction rule. Option (B) has a similar clockwise outline, but joins the strokes at the vertices rather than retaining the separated arrows of the series. Option (D) preserves the count, the required clockwise sense and the separation of the arrow strokes simultaneously.

**Step 4:** Conclusion The next figure contains five separate clockwise arrows. Hence, the correct option is (D).

**Quick Tip to Solve:** In arrow series, check arrow count, circulation and whether adjacent strokes touch; a matching outline alone is insufficient.

**59. Identify the number of surfaces in the given 3D object.** [4 marks]



(A) 12

(B) 13

(C) 10

(D) 9

**Correct Answer:** (B) 13

**Solution:**

**Concept:**

- A surface is a distinct exposed planar face, not merely a polygon visible in the perspective drawing.
- Count the exterior of the stepped body systematically, then add the four inner walls of the rectangular opening. Hidden faces are still surfaces.

**Step 1:** Count the outer profile surfaces Imagine the object before making its rectangular opening. Its side profile has seven boundary segments: the bottom, the low front vertical edge, the inclined front, the intermediate horizontal ledge, the upright riser, the upper horizontal edge, and the rear vertical edge. Extending this profile across the width produces seven outer surfaces. The two end faces complete the exterior, giving nine surfaces before the opening is considered.

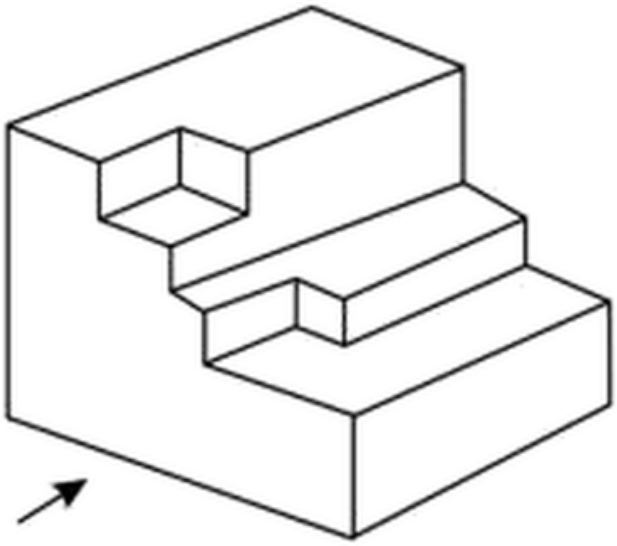
**Step 2:** Include the internal walls of the opening The rectangular opening adds four inward-facing planar walls, one along each side of its rectangular boundary. They are surfaces of the object even though only some of them are visible from the shown viewpoint. The top rim is not four additional faces: its connected coplanar portions constitute the upper surface already counted. Likewise the opening is empty space and must not itself be counted as a face.

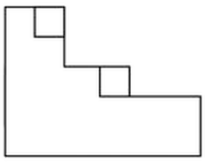
**Step 3:** Add the groups and reject incomplete counts The total is therefore nine exterior surfaces plus four interior walls, giving thirteen surfaces. Counting only nine ignores the opening walls. Counts such as ten or twelve omit some hidden or recessed surfaces rather than describing the full solid. Classifying the faces by their location avoids counting an edge or a visible subdivision as a new surface.

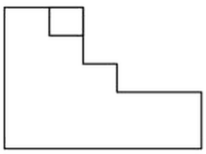
**Step 4:** Conclusion The object has 13 surfaces. Hence, the correct option is (B).

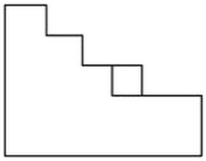
**Quick Tip to Solve:** For a stepped solid with a rectangular opening, count the original exterior first and then add the inward-facing walls.

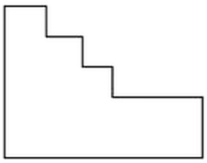
**60. The question figure shows the 3D view of an object. Identify the view of the object looking in the direction of the arrow.** [4 marks]

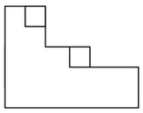


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- An orthographic view projects the solid along the indicated arrow; depth along the viewing direction collapses.
- The outer silhouette and the visible internal edges must both match. A recessed feature may create an internal line even when material behind it preserves the silhouette.

**Step 1:** Establish the outline in the arrow direction Look along the upward-right direction marked by the arrow. The left side of the resulting elevation is tallest, and its outline descends in steps towards the right. The topmost and intermediate ledges retain material behind their front recesses. Hence the outline follows the overall stepped body rather than dropping at the first edge of each notch.

**Step 2:** Locate the two recessed details The upper notch projects as a small rectangular feature beneath the highest horizontal part, near the first main drop. The lower notch produces another

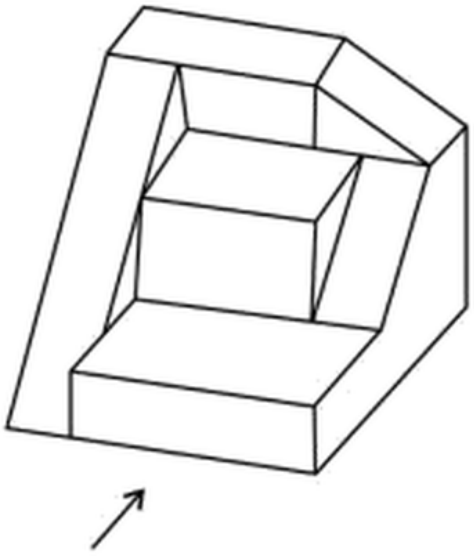
rectangular detail just below the intermediate ledge, near the second drop. These two visible recess boundaries must both appear in the elevation. Their presence is independent of the fact that the body itself still provides the larger stepped silhouette behind them.

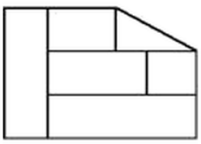
**Step 3:** Match the complete projection Option (A) has the correct descending outline and both rectangular internal details in their proper positions. Option (B) loses the lower recessed detail. Option (C) retains a lower detail but changes the upper outline as if the upper recess cut through the whole depth. Option (D) removes the internal recess information altogether and changes the outline. Thus only the first answer figure records all the visible features together.

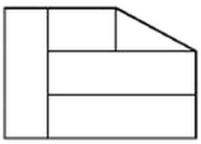
**Step 4:** Conclusion The required view is the first answer figure. Hence, the correct option is (A).

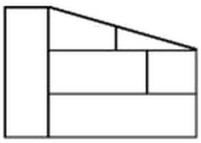
**Quick Tip to Solve:** For a notched block, trace the silhouette first; then project each recess to decide which extra internal edges remain visible.

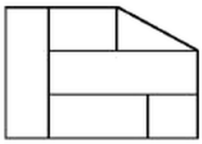
**61. The 3D figure shows the view of an object. Identify the correct view looking in the direction of arrow, amongst the answer figures.** [4 marks]

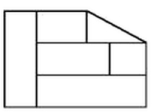


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- Projection in the arrow direction removes depth while retaining heights and horizontal positions.
- Check the outer profile separately from the divisions between visible faces. A correct silhouette can still contain an incorrect internal partition.

**Step 1:** Trace the overall elevation From the arrow direction, the long inclined member on the left projects as a tall vertical strip. Across the upper region the outline is horizontal at first and then slopes down towards the right. The bottom outline is horizontal. These features fix the orientation: the sloping part belongs to the upper-right exterior and must not extend across the whole top.

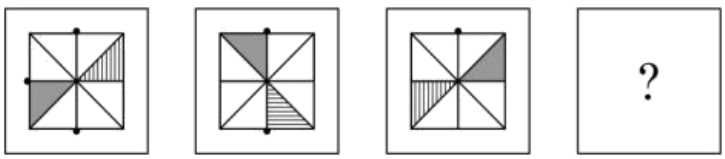
**Step 2:** Project the central and lower faces The low front block forms an unbroken lower rectangular band. Above it, the central raised block creates a middle horizontal band, with its right-hand side separated from the adjoining right member by a vertical edge. In the upper band there is a further vertical division where the horizontal top member meets the sloping right portion. These divisions occur at different horizontal positions, as shown in the solid.

**Step 3:** Compare the candidate elevations Option (A) reproduces the left strip, the horizontal-then-sloping top, the right division in the middle band and the continuous lower band. Option (B) omits the middle vertical division. Option (C) replaces the horizontal top portion by a continuous slope. Option (D) puts a vertical division in the bottom band instead of the middle band. Those changes do not correspond to the faces visible from the indicated direction.

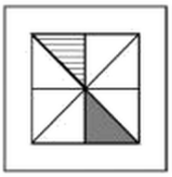
**Step 4:** Conclusion The correct elevation is the first answer figure. Hence, the correct option is (A).

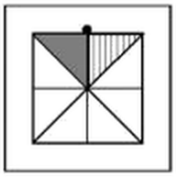
**Quick Tip to Solve:** Compare the outer boundary first, then check every internal edge at its correct height; this quickly separates near-identical elevations.

**62. Choose the correct option from the answer figures which completes the sequence.** [4 marks]




(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- The inner square is divided into eight triangular sectors by its horizontal, vertical and diagonal lines.
- Track the solid-grey and hatched sectors separately. Each follows its own progression around the fixed centre.

**Step 1:** Follow the solid-grey sector In the first figure the grey triangular sector is on the lower-left side. It then moves to the upper-left side in the second figure and to the upper-right side in the third. Thus its position advances around the centre by a quarter turn at each stage. Its next position is the lower-right sector shown in option (B). The square frame and its radial dividing lines do not rotate as a whole.

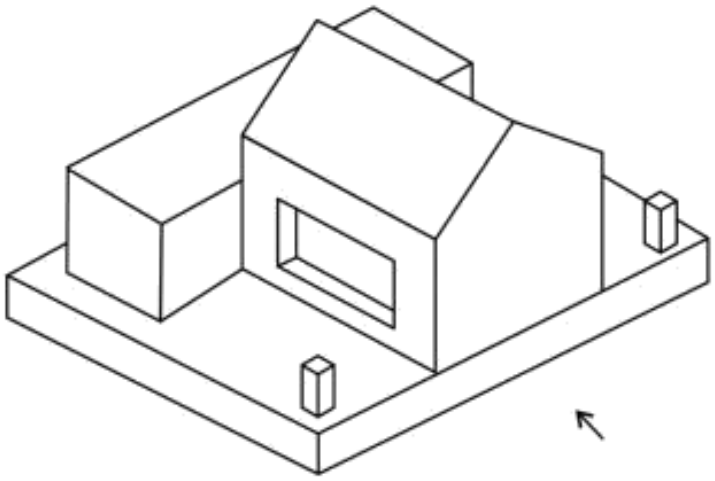
**Step 2:** Follow the hatched sector independently The hatched sector begins on the upper-right, moves to the lower-right, and then to the lower-left. Continuing the same progression places it in the upper-left sector of the missing figure. Its hatch direction must be read as part of the sector in the proposed answer, without confusing it with the solid-grey region. Option (B) pairs this upper-left hatched sector with the required lower-right grey sector.

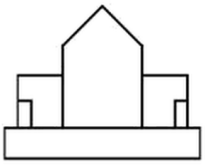
**Step 3:** Check the full combination against the options Option (A) places the grey region at the upper-right and the hatching at the lower-right, which does not advance both features to their next positions. Option (C) returns the grey region to the upper-left with hatching on the upper-right. Option (D) returns to the original lower-left grey and upper-right hatched arrangement. Option (B) is the only choice satisfying both independent progressions at once.

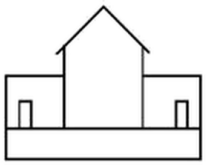
**Step 4:** Conclusion The missing figure has upper-left hatching and lower-right grey shading. Hence, the correct option is (B).

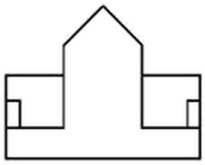
**Quick Tip to Solve:** Record the grey and hatched positions in separate lists; do not try to rotate the whole picture mentally.

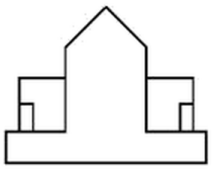
**63. The question figure shows the 3D view of an object, identify the correct view looking in the direction of the arrow?** [4 marks]

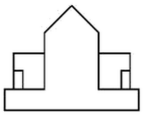


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (D) 

**Solution:**

**Concept:**

- A directional view of a model preserves the silhouette and only those boundaries visible from the indicated side.
- Faces that meet in the same projected plane need not be separated by an invented horizontal line. The base, central gable and side blocks must be considered together.

**Step 1:** Identify the face selected by the arrow The arrow points towards the gable end of the central pitched-roof structure. In this view the central building therefore has a rectangular lower portion topped by a triangular peak. The lower adjoining masses appear on its left and right, and the two short posts project near the outside edges. Looking at the windowed face instead would give the wrong orientation.

**Step 2:** Trace the base and visible boundaries The base extends beyond the adjoining masses at both sides. The central gable rises directly from this base in the projected front face. Its lower outline is continuous with the base, rather than being cut across by an additional full-width horizontal boundary beneath the central wall. The short posts remain visible at the outer sides of the lower blocks, which

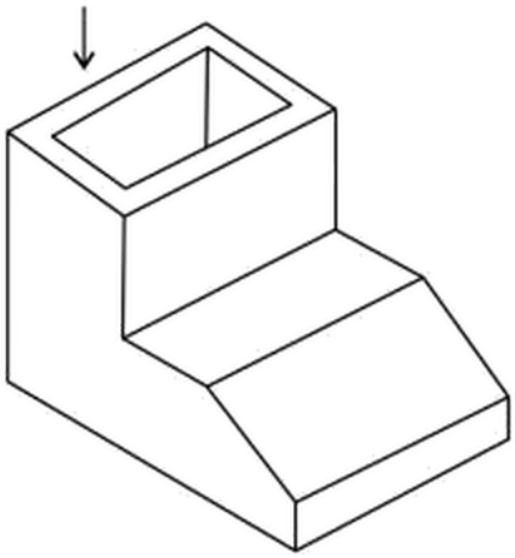
themselves are lower than the central roof.

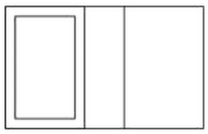
**Step 3:** Eliminate the inconsistent projections Option (D) preserves the projecting base, the central gable and the two outer post details without adding a horizontal line across the foot of the central wall. Option (A) inserts that extra full-width division. Option (B) changes the roof edges and places the small posts away from the outer boundaries. Option (C) loses the side projection of the base and changes the connection of the lower masses. Only option (D) matches the complete elevation.

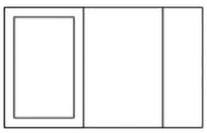
**Step 4:** Conclusion The view in the arrow direction is the fourth answer figure. Hence, the correct option is (D).

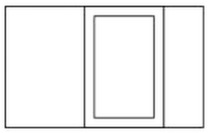
**Quick Tip to Solve:** For a model elevation, check the base overhang and whether each proposed internal line represents a real visible edge.

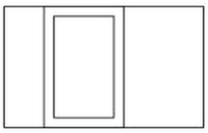
**64. The question figure shows the 3D view of an object. Identify the top view of the object in the direction of the arrow.** [4 marks]

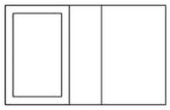


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- A top view projects vertically downward. Heights disappear, while horizontal footprints and visible changes of surface remain.
- A sloping face has a finite horizontal projection. Its image must not be omitted simply because it is inclined rather than horizontal.

**Step 1:** Locate the opening in the plan The arrow indicates a view from above. The rectangular hollow occupies the high rear portion of the body. Its rim appears as an outer rectangular band surrounding a smaller rectangular opening. When matching the options in their displayed orientation, this hollow portion occupies the left-hand end of the overall plan, rather than the middle or the opposite end.

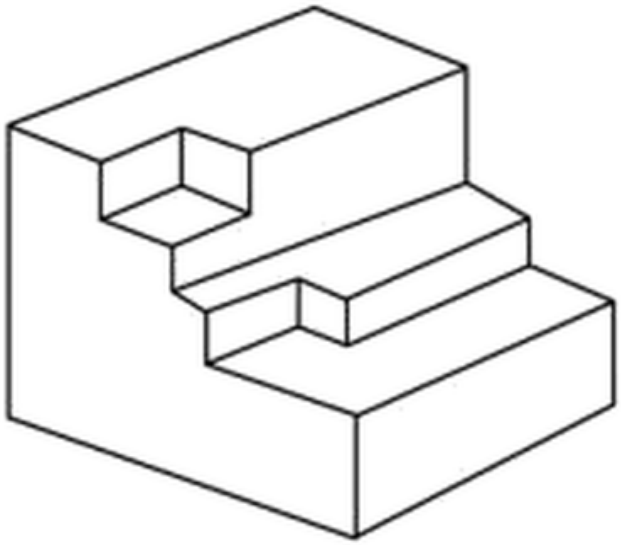
**Step 2:** Project the ledge and inclined front surface Beyond the hollow portion lies the narrow horizontal ledge. A visible line separates it from the inclined front face, whose horizontal projection occupies the larger region towards the right. The low front vertical face has no appreciable plan depth and therefore does not create an extra broad strip in the top view. The plan consequently contains the hollow rear region, a narrow middle strip and a wider plain front region.

**Step 3:** Compare the four proposed plans Option (A) puts the opening at the left, follows it with a narrow ledge strip and then the wider projected inclined face. Option (B) makes the region immediately after the opening broad and adds a narrow strip at the far end. Option (C) locates the hollow in the middle, while option (D) places it at the wrong end. Those arrangements move actual features instead of merely removing height, so they cannot be the top view.

**Step 4:** Conclusion The correct top view is the first answer figure. Hence, the correct option is (A).

**Quick Tip to Solve:** In a top view, project every edge vertically and keep the horizontal width of an inclined face; do not replace it by its true sloping length.

**65. Identify the total number of surfaces in the given 3D object.** [4 marks]



(A) 12

(B) 13

(C) 15

(D) 16

**Correct Answer:** (C) 15

**Solution:**

**Concept:**

- A surface is one continuous planar face of the solid. Count recessed faces and hidden exterior faces as well as the faces visible in the perspective drawing.
- Group faces by orientation. A corner or a change of level separates faces, but an irregular outline within one plane does not itself create another face.

**Step 1:** Count the horizontal faces Start with the three main horizontal levels: the highest top, the intermediate tread and the lowest tread. The floor of the upper recess contributes another horizontal face. Include the underside of the entire object, which is hidden in this view. This gives five horizontal faces. The lower cut meets the lowest tread, so its floor is part of that same connected plane; it must not be counted a second time.

**Step 2:** Count the upright faces Trace the boundary from one side to the other, including the back. There are the two main side faces, the rear face, the lowest front face and the two main upright step faces. The two recesses introduce four additional upright wall faces. Thus the upright-face count is six plus four, or ten. Do not count the line where two drawn edges meet as a face, and do not omit a wall merely because it is inside a recess.

**Step 3:** Combine and compare the options The total is

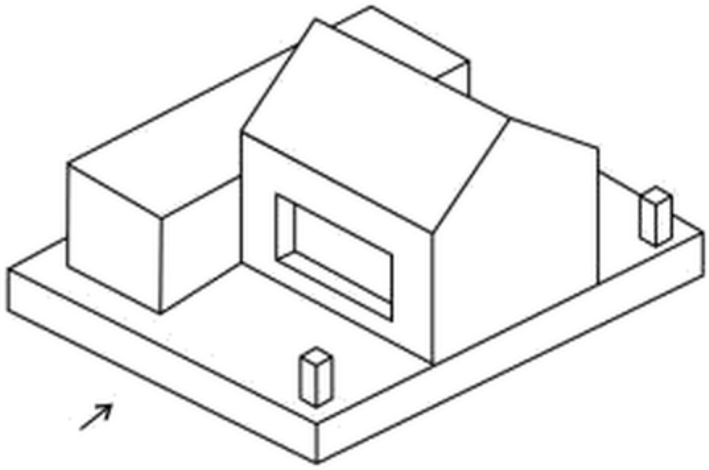
$$5 + 10 = 15.$$

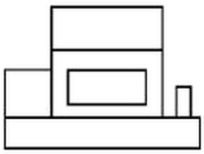
The values 12 and 13 omit exterior or recessed faces. The value 16 double-counts the lower recess floor even though it joins the lowest tread in the same plane. Counting by orientation prevents both errors and includes the hidden bottom.

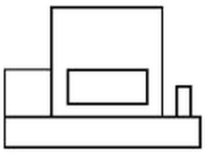
**Step 4:** Conclusion The object has 15 surfaces. Hence, the correct option is (C).

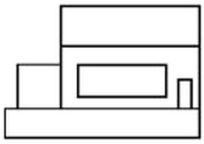
**Quick Tip to Solve:** Count horizontal and upright faces separately; check whether a recess floor joins an existing tread before adding it.

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

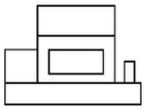


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- An orthographic view projects the object along parallel lines in the stated arrow direction. Depth along the viewing direction collapses; widths and heights remain.
- A sloping roof can project as a rectangular band in elevation. Visible openings remain visible, while objects behind the main building may be hidden.

**Step 1:** Locate the viewing direction The arrow approaches the face containing the rectangular window. Therefore the required elevation must show that window, rather than the blank side of the building. The smaller block projects on the left of the main building. The base remains a horizontal strip under both. One of the small posts projects at the right, with its base on the platform.

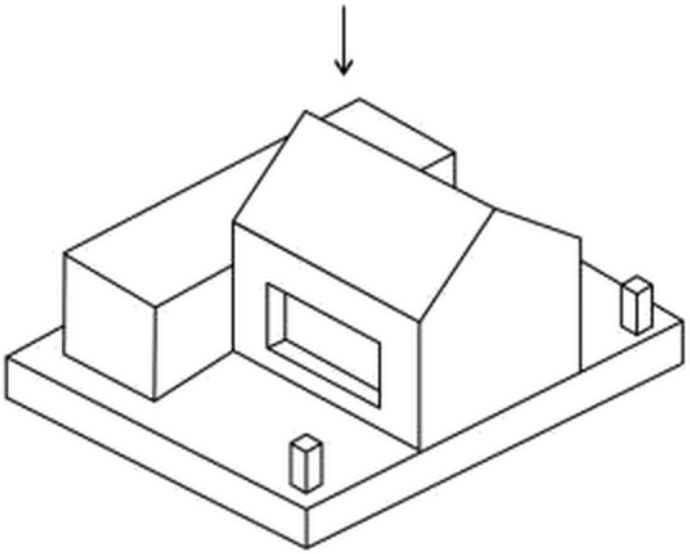
**Step 2:** Project the roof and separate the objects Looking straight toward the window wall, the roof occupies an upper rectangular band. Its lower edge is a horizontal line above the window, not a continuation of the window opening. The main wall and roof have the same projected side limits in this elevation. The right-hand post stands outside the main wall outline rather than being drawn inside the building. Objects farther back may overlap in projection; the view does not preserve their apparent perspective spacing.

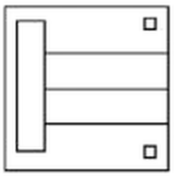
**Step 3:** Eliminate the mismatching elevations Option (B) omits the horizontal boundary between roof and wall. Option (C) extends the main outline too far to the right and brings the post inside it. Option (D) omits the window on the face toward which the arrow points. Option (A) simultaneously preserves the left block, roof band, window, right post and base. These independent features settle the view without relying on the apparent lengths of receding edges.

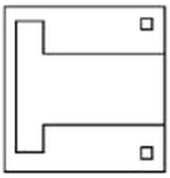
**Step 4:** Conclusion The elevation seen from the arrow is the figure in option (A). Hence, the correct option is (A).

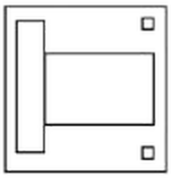
**Quick Tip to Solve:** Identify a unique feature on the face toward the arrow, then check roof boundaries and the position of the small post.

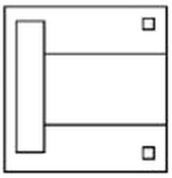
**67. In the question figure it is a 3D view of an object. Identify the correct top view among the given options.** [4 marks]

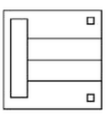


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- A top view is the vertical projection onto a horizontal plane. It records footprints and visible roof edges, not the height of a front wall.
- The ridge of a pitched roof remains a line in its top view. Vertical posts appear as their small square cross-sections.

**Step 1:** Trace the platform and the left block The outer boundary becomes the rectangular platform. The long smaller block lies along the left side and keeps a separate long rectangular footprint. The two upright posts project as small squares near the two right corners. Neither post becomes a tall rectangle in the plan, since its height is along the viewing direction.

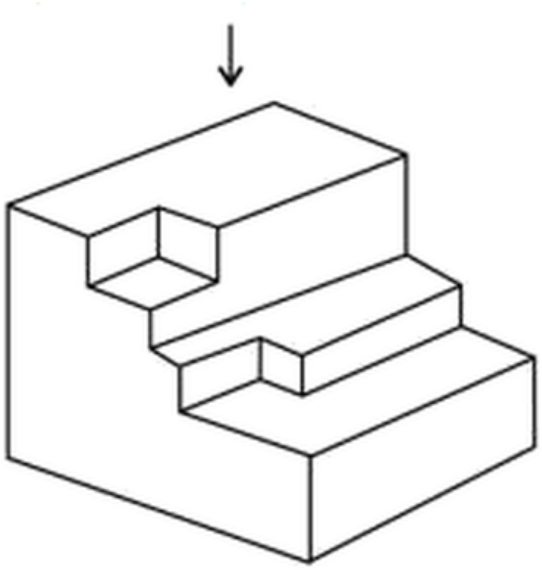
**Step 2:** Project the pitched roof The main building occupies a rectangular region to the right of the long block. Its roof has two slopes meeting at a ridge. From directly above, both roof slopes are visible, with their common ridge running across the footprint between the roof boundaries. Consequently the main region requires three parallel lines: its two outer limits and the central ridge. The window is vertical and does not form an extra inner rectangle in a top view.

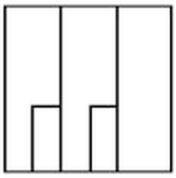
**Step 3:** Compare every option Option (A) shows the left long rectangle, the two right-hand square posts and all three parallel roof lines. Option (B) merges boundaries into an incorrect joined outline and loses the ridge. Option (C) substitutes a closed inner rectangle, as if a wall opening were visible from above. Option (D) has the outer roof limits but omits the central roof ridge. The roof line is therefore the decisive difference between (A) and the tempting option (D).

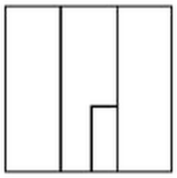
**Step 4:** Conclusion The top view is option (A). Hence, the correct option is (A).

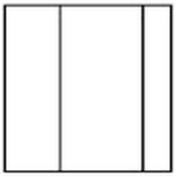
**Quick Tip to Solve:** In a roof plan retain the ridge: a pitched roof normally has an internal line even though the wall window disappears.

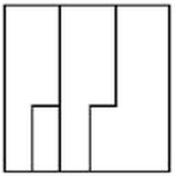
**68. The question figure shows the 3D view of an object. Identify the most appropriate top view of the object from the given direction of the arrow.** [4 marks]

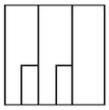


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- The top view removes height while retaining the horizontal location of every visible boundary between levels.
- A recess that is open upward remains visible in plan. Two recesses at different heights can both contribute notches to the projected step boundaries.

**Step 1:** Draw the outer footprint mentally Looking vertically downward as the arrow indicates, the object fills a rectangular footprint. The oblique lines of the perspective picture become parallel boundaries in this plan; their perspective angles are not copied. The three main levels form three adjoining strips across this rectangle. The outer boundary remains complete despite the different heights of the strips.

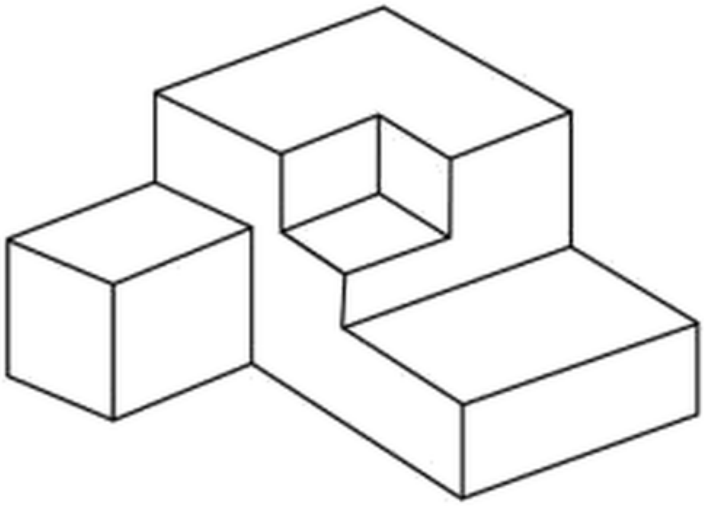
**Step 2:** Retain both recessed boundaries There is a recess at the exposed corner of the highest level and another at the next level. Each changes the boundary of its corresponding strip locally. In plan, these appear as two short rectangular offsets near the same end of two adjacent boundaries. The floor of a recess is visible from above, so it cannot be hidden by simply joining a straight edge across its opening. On the other hand, no extra outer step should be introduced: the rectangular outer footprint is unchanged.

**Step 3:** Match the offsets to the options Option (A) has both local rectangular offsets, one on each of the two adjacent level boundaries, and preserves their alignment. Option (B) retains only one of them. Option (C) reduces the object to uninterrupted strips and omits both recesses. Option (D) continues a displaced boundary over too much of the strip instead of preserving the two local offsets. Thus only (A) retains all the visible upward-facing changes of level.

**Step 4:** Conclusion The appropriate top view is option (A). Hence, the correct option is (A).

**Quick Tip to Solve:** Project every upward-open recess before comparing choices; counting only the large steps loses the small offsets.

**69. Identify the total number of surfaces in the given object.** [4 marks]



(A) 13

(B) 14

(C) 11

(D) 10

**Correct Answer:** (B) 14

**Solution:**

**Concept:**

- Count the exterior planar faces of the combined solid, including the bottom and faces at the rear. Interfaces inside joined blocks are not exterior surfaces.
- A concave notch can add faces, while coplanar connected pieces remain one surface even if their outlines are irregular.

**Step 1:** List the horizontal surfaces The highest part supplies the top face. Below it, the recess has its own floor. The block projecting on the left has a separate top, and the low front-right projection has another top. Finally include the bottom face beneath the combined object. This gives five horizontal exterior surfaces. Do not add horizontal interfaces where one solid portion joins another, since these are within the object.

**Step 2:** Trace the vertical boundary systematically Follow the upright faces around the outside, then inspect the recess. The projecting left block has a front and a left wall. The low front-right portion has its front and right wall. The tall rear portion contributes its rear and exposed side wall together with its front wall. The two inward-facing walls of the recess add two more. There are therefore nine vertical exterior surfaces. A wall with a stepped outline is counted as one planar face when it stays connected in the same plane.

**Step 3:** Add the groups and reject the alternatives The full count is

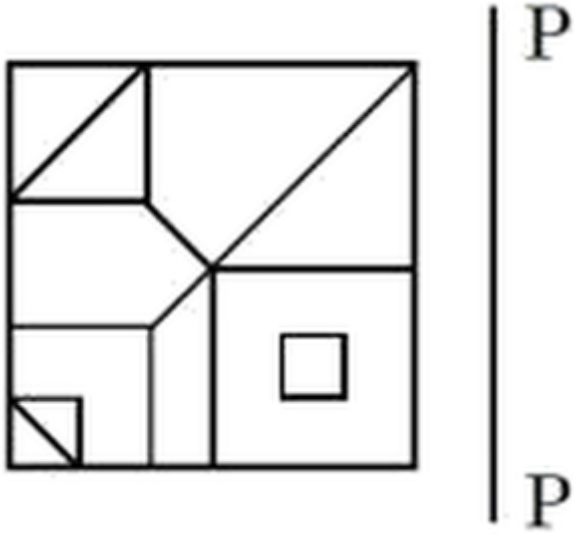
$$5 + 9 = 14.$$

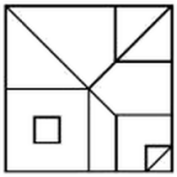
The counts 10 and 11 leave out several recessed or hidden exterior faces; 13 misses one face from the complete boundary inventory. Conversely, treating joined internal walls as visible would overcount. The orientation-based list includes all exterior surfaces without counting an edge or an internal contact as an additional face.

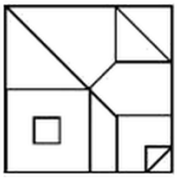
**Step 4:** Conclusion There are 14 surfaces. Hence, the correct option is (B).

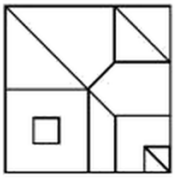
**Quick Tip to Solve:** Include the hidden bottom and rear faces, but exclude contact faces inside joined blocks when counting a compound solid.

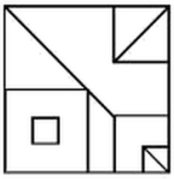
**70. Identify the mirror image of the question figure, amongst the answer figures with respect to P-P.** [4 marks]

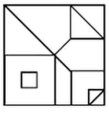



(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- Reflection in the vertical line P-P reverses left and right while leaving every height unchanged. Points close to the mirror remain close to it after reflection.
- A diagonal that rises to the right becomes one that falls to the right under a vertical reflection. Small corner details are useful for distinguishing similar choices.

**Step 1:** Transfer the large features The small isolated square in the lower-right of the question must move to the lower-left of its mirror image. The long diagonal running from the central junction toward the upper-right must run from that junction toward the upper-left after reflection. The large horizontal subdivision on the left of the reflected image remains at the original height. This is a reflection, so the figure must not be turned upside down.

**Step 2:** Reflect the two corner squares The upper-left corner square moves to the upper-right. Its original diagonal runs from its lower-left corner to its upper-right corner; reflection reverses that slope, giving a line from upper-left to lower-right in the new upper-right square. The small lower-left corner square moves to the lower-right. Its diagonal also reverses slope, so the reflected little diagonal runs from lower-left to upper-right.

**Step 3:** Use the corner diagonals to eliminate choices Option (A) has the wrong slope in the upper-right corner square. Option (C) has the wrong slope in the lower-right corner square. Option (D) also fails the corner-diagonal test and does not reproduce the same complete junction pattern. Option (B) has the isolated square at lower-left, the correct main diagonal, and both corner diagonals correctly reversed. Checking only the isolated square would not distinguish all the alternatives.

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

**Quick Tip to Solve:** After swapping left and right, check the slopes of the two tiny corner diagonals; they separate otherwise similar mirror-image choices.

**71. Identify the correct mirror image of the question image with respect to P-P.** [4 marks]




(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- For a vertical mirror, reverse the order of the symbols and reflect each individual symbol horizontally. Reversing order alone is insufficient.
- The top and bottom of each symbol stay at the same heights. Asymmetric strokes of P, E and 4 give especially clear tests of reflection.

**Step 1:** Reverse the sequence and the letter shapes Read the original group from the mirror backward: the reflected sequence begins with the reflected 4, then reflected G, E, P and J. The P bowl must move to the left of its upright. The E upright must be on the right, with its three arms extending left. The J must also have its hook reversed. These conditions rule out a choice that merely reverses the sequence while leaving one of the letters unchanged.

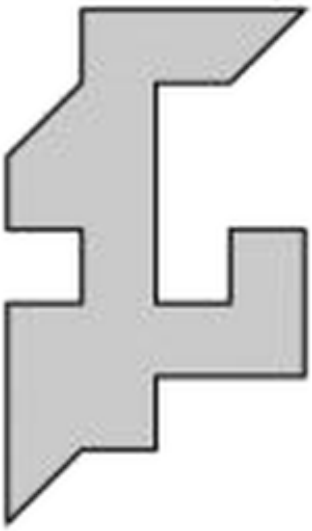
**Step 2:** Check the numeral rather than assuming the key In the supplied question figure, the 4 has a taller upper stroke on its left and a stroke extending downward on its right. Its horizontal reflection must exchange those sides: the tall upper stroke is on the right and the downward extension on the left. Option (B) does this and reflects P and E as well. Option (A) leaves P facing the original way; option (C) leaves E facing the original way. Option (D) reflects the letters but retains the original orientation of the 4, so it fails the individual-symbol reflection test.

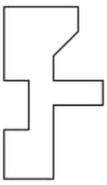
**Step 3:** Resolve the answer-key discrepancy The supplied key selects (D), but its first numeral is not the horizontal reflection of the printed numeral. A vertical reflection preserves heights and exchanges the horizontal positions of the two upright strokes of 4; this gives exactly the numeral in (B). Thus the geometric reflection of the question as printed supports (B), irrespective of the keyed choice. This conclusion follows from a specific stroke comparison, not from a different reading of the symbol order.

**Step 4:** Conclusion For the figure as printed, option (B) reflects every symbol correctly. The supplied answer key selects the fourth figure, but that figure leaves the 4 unreflected. Hence, the correct option is (B).

**Quick Tip to Solve:** Test the numeral 4 separately: both symbol order and the side of each upper and lower stroke must reverse.

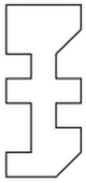
**72. Which of the answer figures fit best to the left side of the given question figure?** [4 marks]



(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- Two pieces fit when their adjoining boundaries match with protrusions occupying recesses and with no gap or overlap.
- Compare the boundary in order from top to bottom. A matching diagonal alone is insufficient if a later rectangular notch has the wrong depth or direction.

**Step 1:** Trace the left boundary of the shaded piece Starting at the upper-left of the shaded figure, the boundary first descends, then slopes down and left to the next vertical segment. It then turns right into a rectangular recess before returning left. Lower down, the outline continues vertically toward the sloping lower end. A piece placed on the left must have the complementary right-hand boundary: its projection fills the recess in the shaded piece and its indentation accommodates the shaded projection.

**Step 2:** Fit the candidate using the diagonal and middle step The right boundary of option (B) begins

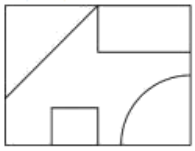
with the required vertical and sloping segments, then has the rectangular projection and recess at the corresponding heights. Sliding it into the left side of the shaded figure aligns the upper slant and the central step at the same time. No rotation that changes which side is the joining boundary is required. The outer edges of the two pieces need not match each other; only the adjoining edges must coincide.

**Step 3:** Reject pieces with a mismatched joining contour Option (A) has a different middle projection extending too far from the joining edge. Option (C) has the recess on the wrong portion of the contour and does not reproduce the alternating steps. Option (D) adds a lower projection and sloping corner that prevent the lower part from fitting while the top is aligned. Option (B) is the only candidate whose complete joining edge follows the shaded boundary in the same top-to-bottom sequence, with every turn complementary.

**Step 4:** Conclusion The piece in option (B) fits the left side of the question figure. Hence, the correct option is (B).

**Quick Tip to Solve:** Trace the entire joining boundary from top to bottom; align the diagonal first, then verify every rectangular step.

**73. In the question figure, the top, front and right side view is given. Identify the most appropriate 3D view of the object from the answer figures.** [4 marks]



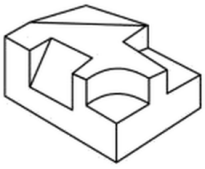
Top view

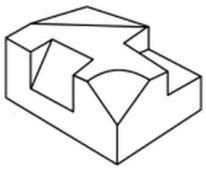


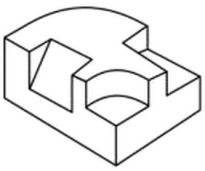
Front view

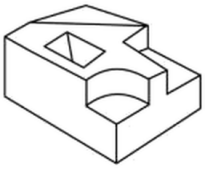


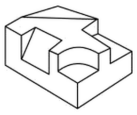
Right side view

(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- Orthographic views show the same solid from mutually perpendicular directions. The top view fixes the plan positions of recesses, while the front and right views fix their heights and openings.
- A curved cut in plan and a diagonal edge in plan must both survive in the corresponding three-

dimensional form. A recess open at an outside edge is different from a closed hole in the top face.

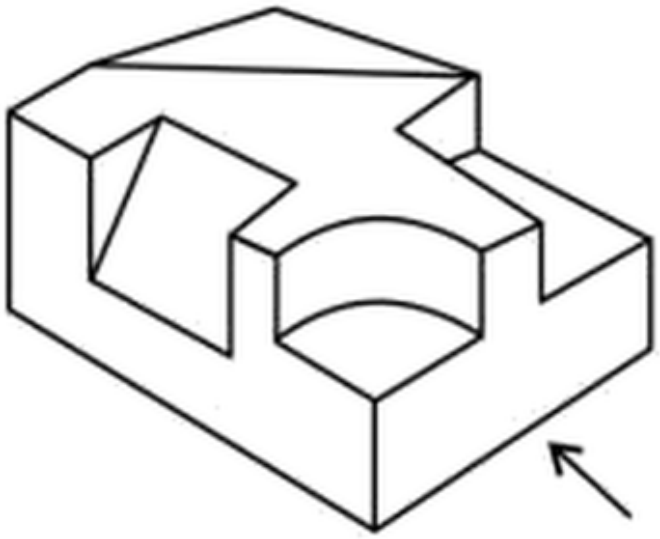
**Step 1:** Read the distinguishing plan features The top view contains a straight diagonal at the rear-left portion, a rectangular open recess at the front-left portion, a quarter-circular recess at the front-right corner, and a rectangular step along the right boundary. Match these features individually before considering the overall perspective shape. The front view has a rectangular lowered opening rather than a closed internal hole.

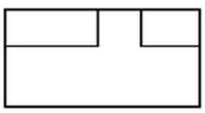
**Step 2:** Test the four solids against all views In (A), the diagonal rear feature, open rectangular cut, curved corner recess and right-side step are all present in the required positions. The circular boundary belongs to the horizontal plan; it does not imply a curved outer elevation. Option (B) replaces the corner recess by an inclined triangular cut, changing its plan. Option (C) changes the straight rear diagonal feature to a curved boundary. Option (D) closes the left opening into an internal hole, so its front projection cannot have the stated open notch. Each rejected option therefore fails a specific view, even though the remaining parts look similar.

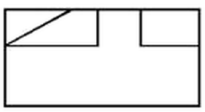
**Step 3:** Conclusion Only solid (A) reproduces the given top, front and right-side views simultaneously. Hence, the correct option is (A).

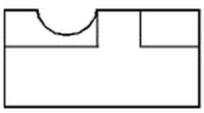
**Quick Tip to Solve:** Compare the curve, the diagonal and the open notch first; these three features distinguish the nearly identical solids.

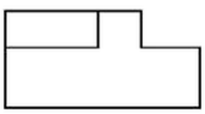
**74. The question figure shows the 3D view of an object. Identify the most appropriate elevation (front view) looking in the direction of arrow.** [4 marks]

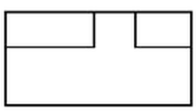


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- An elevation is an orthographic projection: distances along the viewing direction disappear, but vertical heights remain unchanged.
- A circular boundary on a horizontal face need not appear circular in an elevation. Trace the silhouette first, then add visible edges at changes of height.

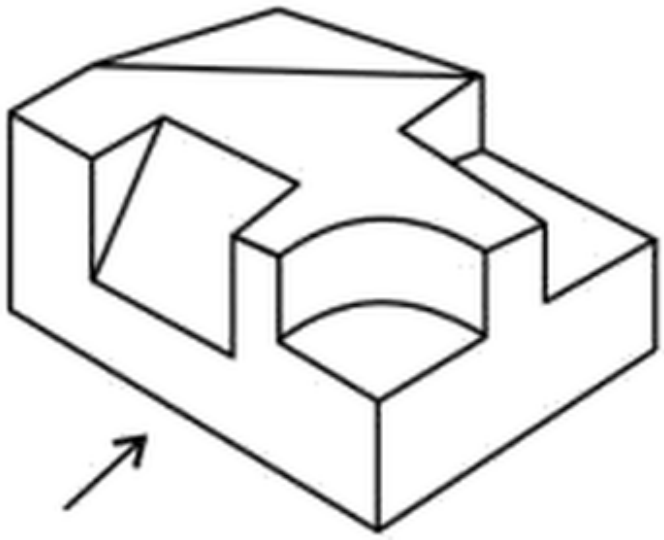
**Step 1:** Fix the viewing direction and outline The arrow points towards the right-hand face of the solid. Look horizontally along that direction, keeping every vertical edge vertical. The full base and the material behind the recesses fill a rectangular overall elevation. The lowered regions appear as two rectangular steps inside that outline, separated by the taller central portion. The object is not being viewed from above.

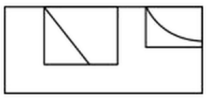
**Step 2:** Project the recess edges and eliminate alternatives The quarter-circular recess lies in plan. Its depth is seen as a horizontal level in this elevation, so a semicircular dip must not be drawn in the projected upper edge. The diagonal rear plan feature also does not create an additional diagonal visible edge in this view. Option (A) has the rectangular outline and both lowered horizontal levels in the correct places. Option (B) incorrectly retains a diagonal across the left recess. Option (C) incorrectly carries the plan curve into the elevation. Option (D) removes the upper outline at the right end, although material behind that lowered foreground part still reaches the full height.

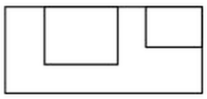
**Step 3:** Conclusion The front elevation along the indicated arrow is the rectangular stepped-edge view in (A). Hence, the correct option is (A).

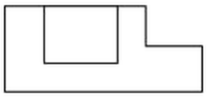
**Quick Tip to Solve:** Before copying a curve into an elevation, check whether it lies horizontally; a plan curve often projects to a straight level.

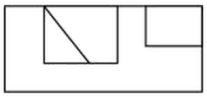
**75. The question figure shows the 3D view of an object. Identify the most appropriate view of the object looking in the direction of the arrow.** [4 marks]

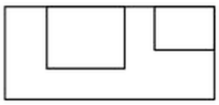


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- The arrow fixes the observation direction. In an orthographic elevation, all points on the same viewing line are superimposed, with height preserved.
- Internal visible edges represent actual changes of face or level. Perspective diagonals and horizontal plan curves are not copied automatically into the elevation.

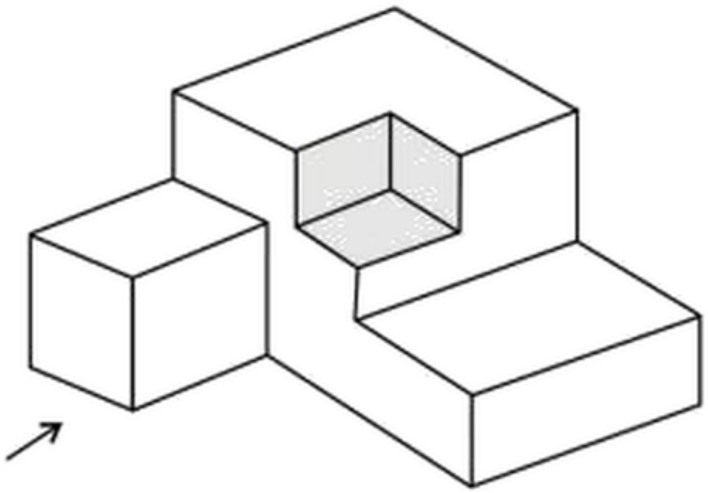
**Step 1:** Project the front-facing openings The arrow approaches the left-front face of the object. The rectangular recess opens into this face and therefore appears as a rectangular U-shaped indentation line inside the full rectangular outline. The rounded corner cut on the right has a horizontal floor at a lower height. In this projection its visible level is straight, giving the second rectangular step at the right. Material farther behind maintains the full upper silhouette.

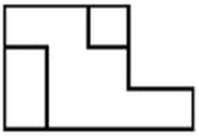
**Step 2:** Compare the offered projections Option (B) contains the full rectangular silhouette, the broad rectangular lowered opening at the left, and the smaller rectangular lowered level at the right. Option (A) adds both a diagonal in the left opening and a curve in the right opening, confusing plan or perspective edges with the elevation. Option (C) lowers the outside right-hand silhouette, overlooking the higher material behind. Option (D) preserves the diagonal in the left opening, which is not a visible slanting boundary in the required front projection. Thus the internal levels, as well as the outer boundary, select a unique answer.

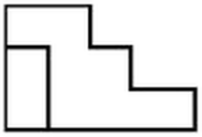
**Step 3:** Conclusion The required view is (B), with rectangular recess boundaries and an unchanged rectangular outside outline. Hence, the correct option is (B).

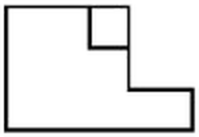
**Quick Tip to Solve:** Trace the outer silhouette and each recess floor separately; a correct outline alone does not identify the right elevation.

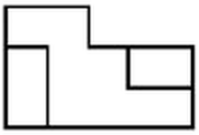
**76. The question figure is the 3D view of an object. Identify the most appropriate front view of the object looking in the direction of the arrow.** [4 marks]

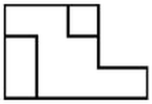


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- A front elevation preserves the left-to-right order and vertical heights of parts but removes their depth along the arrow.
- An object behind a lower foreground block can remain visible above it. Recess edges must be retained when they face the observer, even if the overall silhouette is unchanged.

**Step 1:** Trace the stepped silhouette Look along the arrow from the left-front side. The raised rear mass reaches the greatest height over the left and central portions. The low right-hand platform contributes the long lower extension. Thus the outline has a high left portion followed by a lower right extension. The separate foreground cube does not erase the higher rear mass; its upper and right edges remain visible as an internal rectangular outline at the left.

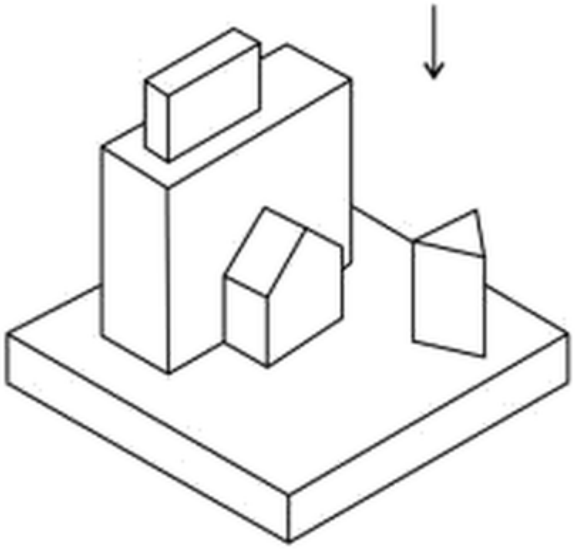
**Step 2:** Include the upper recess and compare The small recessed corner of the high mass produces an additional small rectangular edge near the upper right of the high portion. Option (A) includes both this upper recess and the left foreground cube, while giving the correct two-level outside silhouette. Option (B) introduces an extra descending level and omits the upper recess. Option (C) omits the

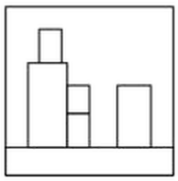
internal edges of the foreground cube. Option (D) places the recess on the low right extension and changes the high mass profile. Rejecting these requires checking the visible internal edges, not merely counting the apparent steps.

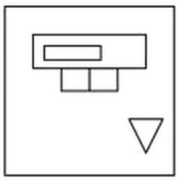
**Step 3:** Conclusion The front view retains the cube outline at the left and the upper recessed corner as in (A). Hence, the correct option is (A).

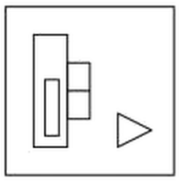
**Quick Tip to Solve:** For overlapping blocks, draw the tallest silhouette first and then add the exposed edges of the shorter foreground block.

**77. Question figure shows 3D view of an object. Identify the most appropriate top view of the given 3D object looking in the direction of an arrow, from the given answers figures.** [4 marks]

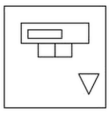


(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (B) 

**Solution:**

**Concept:**

- A top view is obtained by projecting vertically downwards. Heights disappear, leaving horizontal footprints and visible top-surface boundaries.
- A thin upright rectangular slab has a narrow rectangular footprint. A vertical triangular prism has a triangular footprint; it does not become a rectangle merely because a side face looks rectangular in perspective.

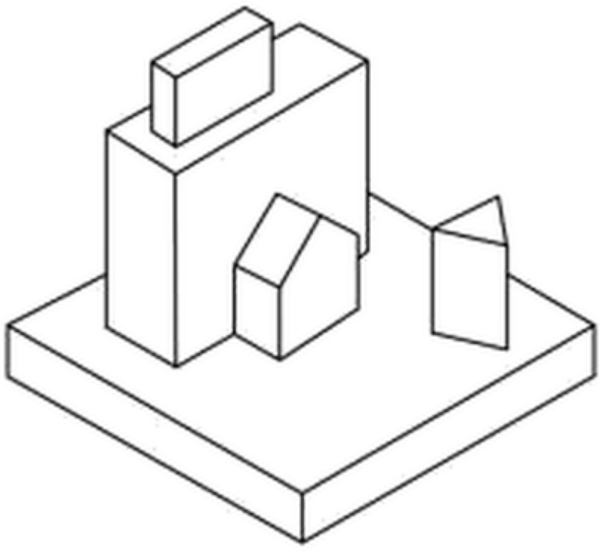
**Step 1:** Identify the footprints from above The square base provides the enclosing plan. The tall rectangular block becomes a long rectangle, and the thinner slab on its top becomes a smaller narrow rectangle within that footprint. The small roofed block beside the tall block contributes a rectangular footprint divided by its roof ridge. The isolated triangular prism contributes a triangle at the opposite side of the base. These are plan features, so no vertical base thickness appears.

**Step 2:** Match the arrangement and orientation Option (B) places the long rectangular block horizontally, the narrow slab inside it, the divided footprint immediately below it, and the triangle farther below and to the right. This is the arrangement obtained in the indicated top projection. Options (A) and (D) retain the base as a strip with upright silhouettes of different heights, so they are elevations rather than plans; (D) also introduces a circular feature absent from the object. Option (C) rotates and relocates the layout relative to the prescribed view, putting the long block vertically and turning the triangular footprint to the right. The answer must match the requested orientation as well as the list of shapes.

**Step 3:** Conclusion The correctly arranged top view is (B). Hence, the correct option is (B).

**Quick Tip to Solve:** In a top view replace every upright object by its footprint, then preserve the relative positions of the footprints.

**78. Identify the number of surfaces in the problem figure.** [4 marks]



(A) 24
(B) 25
(C) 23
(D) 20

**Correct Answer:** (B) 25

**Solution:**

**Concept:**

- Count the distinct exposed faces of each constituent solid, including faces hidden from the observer. Contact faces between joined solids are internal and are not exposed surfaces.
- A rectangular prism has six faces, a triangular prism has five, and a prism with a pentagonal end profile has seven. A connected planar face remains one surface even when an attached object covers a patch of it.

**Step 1:** Separate the components without counting contacts The figure consists of the rectangular base slab, the tall rectangular block, the thin rectangular block on top, the small roof-shaped pentagonal prism in front, and the isolated triangular prism on the right. Use these five components to organize the count. The underside of the base is exposed and counts, even though it cannot be seen. The bottoms of all four objects standing on other solids are contact faces and do not count.

**Step 2:** Add the exposed faces component by component The base contributes six surfaces: its upper face, underside and four side faces. The tall block contributes five after its bottom contact is excluded, and the thin top block contributes another five. The roof-shaped pentagonal prism contributes five: its bottom and the end in contact with the tall block are excluded from its seven faces. The triangular prism contributes four after its bottom contact is excluded. Therefore the total is

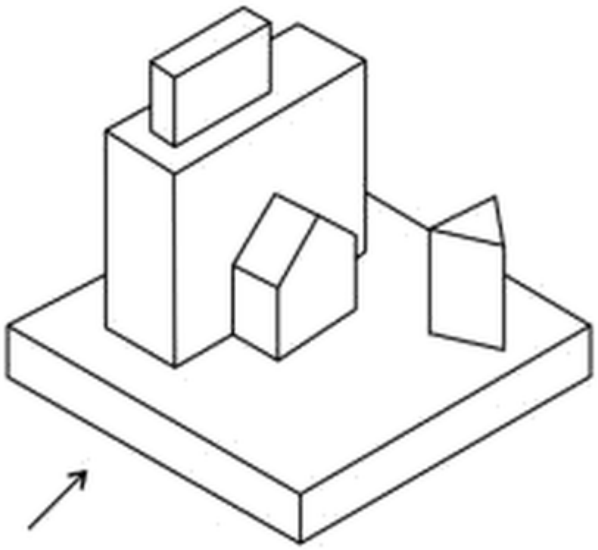
$$6 + 5 + 5 + 5 + 4 = 25.$$

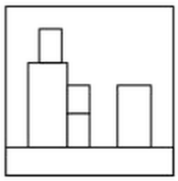
Option (A), 24, misses an exposed face; option (C), 23, misses two. Option (D), 20, undercounts the rear or underside faces. Counting only the visible polygons would also be incorrect.

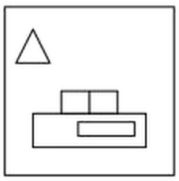
**Step 3:** Conclusion There are 25 exposed surfaces in the complete object. Hence, the correct option is (B).

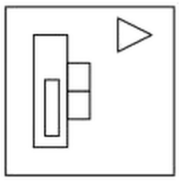
**Quick Tip to Solve:** List the solids separately, subtract only their contact faces, and remember the underside and rear faces.

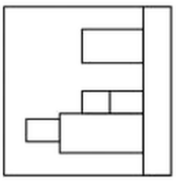
**79. The question figure shows 3D view of an object. Identify the most appropriate elevation of the given 3D object, looking in the direction of an arrow, from the given answer figures.** [4 marks]



(A) 

(B) 

(C) 

(D) 

**Correct Answer:** (A) 

**Solution:**

**Concept:**

- An elevation projects the object horizontally along the indicated arrow. Heights remain visible, whereas depth is suppressed.
- The outer silhouette and the visible edges of smaller objects must be checked separately. A prism can have a triangular plan but a rectangular elevation from a side perpendicular to one of its rectangular faces.

**Step 1:** Determine the order and heights The arrow approaches the left-front side. The base becomes a horizontal strip. Above it, the tall block forms the dominant upright rectangle on the left, and the thin block on top rises above that rectangle. The smaller roof-shaped block appears immediately to the right of the tall block, with a horizontal line marking the change from its vertical portion to the roof level. The separate triangular prism stands farther to the right and gives a rectangular silhouette

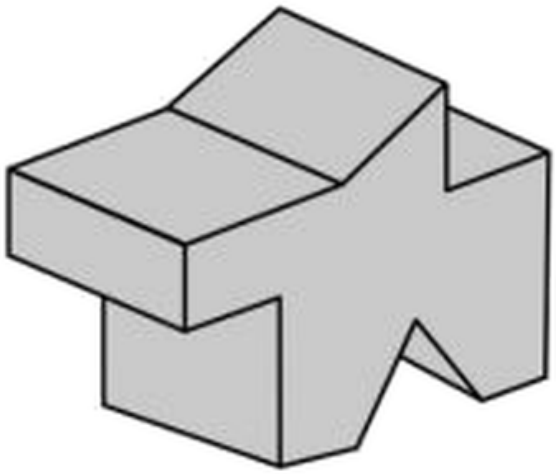
from this direction.

**Step 2:** Test the answer figures Option (A) shows exactly this elevation: a base strip, the tall left rectangle with its narrower upper projection, the shorter divided block beside it, and the isolated right rectangle. Options (B) and (C) show the arrangement of footprints, including an exposed triangle, and therefore represent plan-type views instead of the requested elevation. Option (D) turns the base into a vertical strip and arranges the solids sideways; it does not preserve the vertical direction fixed by the arrow and the base. There is no circular component in the object, so no circular top or outline should be introduced while projecting it.

**Step 3:** Conclusion The elevation seen along the arrow is (A). Hence, the correct option is (A).

**Quick Tip to Solve:** Keep the base horizontal in an elevation and compare the tallest block plus its thin upper projection before the smaller solids.

**80. Find out the total number of surfaces of the 3D object.** [4 marks]



(A) 12

(B) 13

(C) 14

(D) 15

**Correct Answer:** (C) 14

**Solution:**

**Concept:**

- A prism made by extending a polygonal profile has two end faces and one lateral surface for every edge of the profile, including edges around inward notches.
- For a profile with n sides, the number of surfaces is n+2. A non-convex end face is still one planar face; its inward corners do not split it into separate surfaces.

**Step 1:** Trace the complete end profile Use the large shaded end face as the profile. Follow its

boundary continuously rather than counting only the prominent outer corners. Include the left overhang and its underside, the recessed vertical edge below that overhang, the lower central portion, the two sloping sides of the triangular bottom notch, the right vertical side, the upper right step and the inclined upper surface. The complete profile has twelve boundary edges. Inward-facing notch edges count just like outward-facing ones.

**Step 2:** Count the two ends and the lateral surfaces Each of the twelve profile edges sweeps out one lateral face along the depth of the object. Some of these faces are on the far side or underneath the overhang and are hidden in the perspective picture, but they are still surfaces. The two parallel polygonal end faces add two more:

$$N = 12 + 2 = 14.$$

Option (A), 12, counts only the lateral faces and forgets both ends. Option (B), 13, omits one end or one hidden face. Option (D), 15, counts an extra subdivision of a continuous planar end face. Counting visible shaded patches alone is not the required total.

**Step 3:** Conclusion The object has 14 surfaces in total. Hence, the correct option is (C).

**Quick Tip to Solve:** For an extruded irregular solid, count every edge of one end profile and add two; include the edges of inward notches.

## Planning (100 marks)

**81. GIS as a tool used for spatial connectedness for** [4 marks]

(A) Topology

(B) Topography

(C) Ecology

(D) Climatology

**Correct Answer:** (A) Topology

**Solution:**

**Concept:**

- Geographic Information Systems (GIS) organise spatial features together with their locations, attributes and relationships. A spatial relationship says how one feature is related to another, rather than merely describing the height of the ground.
- Topology describes connectivity, adjacency and containment. For example, it records whether two road segments join at a node, whether two land parcels share a boundary, or whether a point lies inside a polygon.

**Step 1:** Identify what spatial connectedness means The decisive word is connectedness. Consider a road network: drawing two lines close together does not by itself establish a usable junction. GIS needs a relationship indicating which road ends actually meet and which routes can therefore be followed. Such node-and-edge connections are topological relationships. They support network tracing and help identify gaps or disconnected segments in mapped data.

**Step 2:** Distinguish the alternative terms Topology is therefore the required term, option (A). Topography, option (B), concerns the physical surface, relief and elevation of land; it is not the name for feature connectivity. Ecology, option (C), studies relationships among organisms and their environment. Climatology, option (D), studies climate and its patterns. GIS can be used in all these subject areas, but the particular relationship asked about is topology.

**Step 3:** Conclusion Spatial connectedness in GIS is described by topology. Hence, the correct option is (A).

**Quick Tip to Solve:** For GIS terminology, associate topology with connections, shared boundaries and containment; associate topography with terrain and elevation.

**82. Smart city scheme has been launched in which year?** [4 marks]

(A) 2012

(B) 2016

(C) 2015

(D) 2014

**Correct Answer:** (C) 2015

**Solution:**

**Concept:**

- The Smart Cities Mission is an Indian urban-development programme launched by the Government of India in 2015. Its purpose includes better urban infrastructure, services, quality of life and sustainable development.
- A programme launch is distinct from later selection rounds, project approvals and implementation dates. A city may join a later round without changing the national launch year.

**Step 1:** Recall the launch event The Smart Cities Mission was launched on 25 June 2015. The question asks when the scheme was launched, so the required fact is the year of that event, not the year when a particular city received funds or completed a project. The date places the launch in the calendar year 2015, which appears as option (C).

**Step 2:** Eliminate the other years The years 2012 and 2014, options (A) and (D), both precede the launch and cannot be selected. The year 2016, option (B), is associated with subsequent activity in the mission, including city selection and implementation, but is later than the launch itself. Thus none of these alternatives answers the wording of the question. Keeping announcement, launch and implementation milestones separate prevents a common chronology error in questions about government programmes.

**Step 3:** Conclusion The Smart Cities Mission was launched in 2015. Hence, the correct option is (C).

**Quick Tip to Solve:** Remember the complete launch date, 25 June 2015; it separates the start of the mission from later city-selection rounds.

**83. With reference to the area which one among the following is the largest?** [4 marks]

(A) Zonal Plan

(B) Master Plan

(C) Regional Plan

(D) Layout Plan

**Correct Answer:** (C) Regional Plan

**Solution:**

**Concept:**

- Spatial plans operate at different geographical scales. A regional plan coordinates development across a broad region that may include several towns, villages and their surrounding countryside.
- A master plan normally guides a city or urban settlement. A zonal plan details a zone within that planning area, while a layout plan arranges plots, streets and local facilities within a smaller development site.

**Step 1:** Compare the scales of planning The comparison is about the area covered, rather than the detail of drawings or the number of regulations. Regional planning considers relationships between settlements, transport corridors, resources and economic activities across an extensive territory. It therefore works at a broader geographical level than planning for one city. Among the listed plans, the regional plan has the largest normal spatial coverage.

**Step 2:** Place the remaining plans in order A master plan covers the city or urban planning area and is generally more local than a regional plan. A zonal plan develops the proposals for a particular zone of that city, so option (A) is smaller in scope. A layout plan concerns a still more local site, showing matters such as individual plots and access roads, so option (D) is also excluded. Option (B), the master plan, lies between regional and zonal planning in this standard hierarchy. The largest listed scale is option (C).

**Step 3:** Conclusion The Regional Plan covers the largest area among the four types listed. Hence, the correct option is (C).

**Quick Tip to Solve:** Use the usual scale order: regional plan, master plan, zonal plan, then layout plan, moving from broader territory to finer detail.

**84. Given below are two statements:**

**Statement I: Full form of NFDB is "National Fisheries Development Board".**

**Statement II: Full form of NFDB is "National Forest Development & Board.**

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

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

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

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

**Solution:**

**Concept:**

- NFDB stands for National Fisheries Development Board. The name identifies an organisation concerned with fisheries development, including the development of the fisheries and aquaculture sector.
- In a two-statement question, test each complete statement independently before selecting the option. A matching initial letter is not enough: the full expansion must be the actual institutional name.

**Step 1:** Evaluate Statement I Statement I expands NFDB as National Fisheries Development Board. This is the correct full name, so Statement I is true. The word Fisheries is essential: it identifies the field of the organisation and distinguishes it from institutions dealing with forests. Merely noticing that both possible subject words begin with F would not determine the correct expansion.

**Step 2:** Evaluate Statement II and match the pair Statement II gives National Forest Development and Board, which is not the expansion of NFDB. It changes Fisheries to Forest and also introduces an extra conjunction in the name. Statement II is therefore false. The truth combination is true for I and false for II. Option (A) wrongly treats II as true; option (B) wrongly rejects I; option (D) reverses both truth values. Only option (C) states the required combination, so it follows directly from checking the institutional name.

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

**Quick Tip to Solve:** Expand the acronym completely before testing the statements: NFDB refers to Fisheries, which is the decisive word here.

**85. The Gandhian plan was presented by** [4 marks]

(A) Sriman Narayan Agarwal

(B) J.L. Nehru

(C) M.M. Roy

(D) P.V. Narasimha Rao

**Correct Answer:** (A) Sriman Narayan Agarwal

**Solution:**

**Concept:**

- The Gandhian Plan was presented by Sriman Narayan Agarwal in 1944. It drew on Gandhian ideas of village-centred development, decentralisation and the importance of cottage and small-scale activities.
- Questions on early Indian planning proposals require matching the named plan with its proponent. A general association with economic policy or national leadership does not establish authorship of a particular plan.

**Step 1:** Identify the specific proposal The Gandhian Plan advocated a development approach rooted in rural communities and decentralised production. Its proponent was Sriman Narayan Agarwal. This historical association identifies option (A). The title refers to the ideas influencing the proposal; it does not mean that every political leader associated with national planning presented this particular plan.

**Step 2:** Check the alternative names J. L. Nehru was associated with the National Planning Committee and later national planning, but he was not the presenter of the Gandhian Plan, so option (B) is excluded. The Roy alternative is not the author of this plan; the People's Plan is associated with M. N. Roy, a different proposal. P. V. Narasimha Rao belongs to a much later period of Indian economic policy and is not its proponent, excluding option (D). The exact plan-author pairing therefore remains Sriman Narayan Agarwal.

**Step 3:** Conclusion The Gandhian Plan was presented by Sriman Narayan Agarwal. Hence, the correct option is (A).

**Quick Tip to Solve:** Keep the early proposals separate: Gandhian Plan goes with Sriman Narayan Agarwal; a broad association with planning is not enough.

**86. In which 5 year plan, the growth, social justice and equality was focused.**

**(A) Second Five year plan**

**(B) Ninth Five year plan**

**(C) Third Five year plan**

**(D) Fourth Five year plan**

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

(A) A only

(B) B and D

(C) B only

(D) C only

**Correct Answer:** (C) B only

**Solution:**

**Concept:**

- The Ninth Five-Year Plan covered 1997–2002. Its central emphasis was growth with social justice and equity, connecting economic expansion with a fairer distribution of its benefits.
- The letters inside the question name the candidate plans. The answer options then select from those letters, so the letter of a listed plan must not be confused with the final option letter.

**Step 1:** Identify the plan from its emphasis The phrase growth with social justice and equity identifies the Ninth Five-Year Plan. In the list supplied within the question, the Ninth Plan is entry (B). The intended emphasis combines growth with concern for disadvantaged groups and distribution, rather than treating aggregate production alone as the objective. This makes the Ninth Plan the relevant match to the wording about growth, social justice and equality.

**Step 2:** Translate the list entry into the answer code Entry (B) alone is selected. The final answer option saying B only is option (C), not option (B). The Second Plan, entry (A), is especially associated with industrialisation and heavy industry. The Third Plan, entry (C), emphasised a self-reliant and self-generating economy. The Fourth Plan, entry (D), is associated with growth with stability and progressive self-reliance. Therefore A only, C only and the combination B and D do not match the distinctive emphasis asked for.

**Step 3:** Conclusion The Ninth Five-Year Plan is the required plan; the answer code is B only. Hence, the correct option is (C).

**Quick Tip to Solve:** First identify the Ninth Plan as entry B, then select the final option that says B only; this avoids confusing the two sets of letters.

**87. In Urban Land Development, the model of sector theory was proposed by** [4 marks]

(A) Charles Corea

(B) Ebenezer Howard

(C) Le-Corbusier

(D) Homer Hoyt

**Correct Answer:** (D) Homer Hoyt

**Solution:**

**Concept:**

- The sector theory of urban land use was proposed by Homer Hoyt in 1939. It describes urban development in sectors or wedges extending outward from a central area, often influenced by transport routes.
- A land-use model is different from a designed city or an architectural style. To identify its author, connect the name of the model with its particular explanation of urban spatial organisation.

**Step 1:** Recognise the sector theory In the sector model, similar land uses can extend outward along particular directions rather than forming complete concentric rings. Transport corridors and established patterns of residential desirability help explain these wedges. This characteristic identifies Hoyt's sector theory. Since the question asks who proposed the model, the relevant name is Homer Hoyt, appearing in option (D).

**Step 2:** Separate the other urban thinkers Charles Correa, option (A), was an architect and urban planner, but is not the originator of the sector model. Ebenezer Howard, option (B), is associated with the Garden City idea rather than sector theory. Le Corbusier, option (C), is associated with modernist architecture and urban planning concepts such as the Radiant City, not Hoyt's land-use explanation. These distinctions rule out the three alternatives without confusing an important urban designer with the proposer of this specific analytical model.

**Step 3:** Conclusion The sector theory of urban land development was proposed by Homer Hoyt. Hence, the correct option is (D).

**Quick Tip to Solve:** Associate Hoyt with outward-growing wedges or sectors; associate Howard with Garden Cities, so the two planning ideas stay distinct.

**88. Who was the first Deputy Chairman of Planning Commission?** [4 marks]

(A) Gulzarilal Nanda

(B) Sriman Narayan

(C) M.M. Roy

(D) P.V. Narasimha Rao

**Correct Answer:** (A) Gulzarilal Nanda

**Solution:**

**Concept:**

- Gulzarilal Nanda was the first Deputy Chairman of India's Planning Commission. The office of Deputy Chairman is distinct from the chairmanship, which was held by the Prime Minister.
- A question about the first holder of an office requires the exact institutional role. Being associated with an economic proposal or a later reform period does not make someone the first Deputy Chairman.

**Step 1:** Identify the office precisely The Planning Commission was established in 1950 to guide national economic planning. The question concerns its Deputy Chairman, not its Chairman and not the author of a pre-independence planning proposal. Gulzarilal Nanda was the first person to hold the Deputy Chairman's office. Thus the correct name is the one in option (A).

**Step 2:** Eliminate names linked to other contexts Sriman Narayan, option (B), is associated with the Gandhian planning approach, but was not the first Deputy Chairman. The Roy alternative, option (C), likewise does not identify the first holder of this office; the well-known Roy association in early planning history is with a separate planning proposal. P. V. Narasimha Rao, option (D), served as Prime Minister much later and is remembered for the economic reform period of the 1990s. None of those associations displaces Nanda in the precise office and chronological position asked for here.

**Step 3:** Conclusion Gulzarilal Nanda was the first Deputy Chairman of the Planning Commission. Hence, the correct option is (A).

**Quick Tip to Solve:** Distinguish the two offices: the Prime Minister chaired the Planning Commission, while Gulzarilal Nanda was its first Deputy Chairman.

**89. Grand Innovation Challenge was launched by:-** [4 marks]

(A) "NITI" Aayog

(B) Finance Commission

(C) Planning Commission

(D) National Planning Committee

**Correct Answer:** (A) "NITI" Aayog

**Solution:**

**Concept:**

- The Grand Innovation Challenge is associated with NITI Aayog and its effort to invite innovative responses to development problems.
- NITI Aayog is the National Institution for Transforming India. Its policy and innovation role distinguishes it from bodies concerned with fiscal transfers or historical planning proposals.

**Step 1:** Identify the initiative and its purpose The question asks for the institution that launched the Grand Innovation Challenge, rather than for the agency that finances all government programmes. The initiative invited ideas and innovative solutions to challenges in national development. This association points to NITI Aayog, whose work includes encouraging innovation and developing approaches to public-policy problems.

**Step 2:** Compare all four institutions NITI Aayog is therefore the direct match in option (A). The Finance Commission recommends the distribution of financial resources between the Union and the states; that fiscal function does not identify the launcher of this innovation challenge. The Planning Commission was the earlier institution associated with Five-Year Plans and was replaced by NITI Aayog in 2015. The National Planning Committee belongs to the earlier history of Indian planning. Neither historical planning body is the institution named for this initiative.

**Step 3:** Conclusion The Grand Innovation Challenge was launched by NITI Aayog. Hence, the correct option is (A).

**Quick Tip to Solve:** For an initiative with an innovation and development-policy focus, distinguish NITI Aayog from the Finance Commission, whose central role concerns fiscal distribution.

**90. Who is the father of Indian Planning.** [4 marks]

(A) Jawaharlal Nehru

(B) M.K. Gandhi

(C) Sir M. Vishveshshwariah

(D) B.R. Ambedkar

**Correct Answer:** (C) Sir M. Vishveshshwariah

**Solution:**

**Concept:**

- Sir M. Visvesvaraya is conventionally known as the father of Indian planning because of his early systematic proposals for planned economic development.
- His book, Planned Economy for India, published in 1934, is a key association used to distinguish the origin of planning proposals from later implementation of national plans.

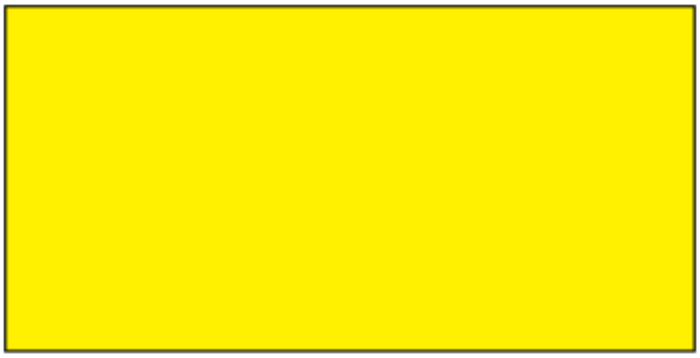
**Step 1:** Recall the early planning proposal Sir M. Visvesvaraya argued for purposeful economic development through a planned programme, with industrialisation and increased national income as major concerns. His 1934 book Planned Economy for India gives a clear historical basis for the title asked about here. The spelling in option (C) refers to this same engineer and statesman.

**Step 2:** Distinguish the other contributions Jawaharlal Nehru played a major role in the National Planning Committee and in the post-independence planning framework, but that later leadership is different from the conventional title in this question. M. K. Gandhi advanced an approach centred on village life and self-reliance; he is not the standard answer to this title. B. R. Ambedkar made major contributions to economics, social justice and constitutional development, but is likewise not the person conventionally called the father of Indian planning. Thus only option (C) fits the specific historical identification.

**Step 3:** Conclusion Sir M. Visvesvaraya is the father of Indian planning in the conventional usage tested here. Hence, the correct option is (C).

**Quick Tip to Solve:** Link Visvesvaraya with Planned Economy for India (1934); distinguish this early proposal from Nehru's later role in national planning.

**91. In master plan, a zone is shown in yellow colour. What is the land use of that zone?** [4 marks]



(A) Residential

(B) Commercial

(C) Industrial

(D) Water Bodies

**Correct Answer:** (A) Residential

**Solution:**

**Concept:**

- A land-use map uses colour as a categorical symbol: each colour identifies an activity or land-use class rather than the physical colour of the buildings.
- In the conventional master-plan colour scheme tested here, yellow represents residential land use. Other principal classes have their own contrasting colours.

**Step 1:** Interpret the colour symbol The only map information needed is that the zone is yellow. There is no need to calculate its area or to identify the shape of its boundary. In the standard planning legend, yellow is used for residential areas, meaning land primarily assigned to housing and associated residential uses. The zone must therefore be identified as residential.

**Step 2:** Eliminate the other land uses Option (A) matches this colour convention directly. Commercial areas are generally represented by a contrasting commercial colour, commonly blue in the planning scheme used for such questions, rather than by residential yellow. Industrial areas are conventionally purple or violet, making option (C) inconsistent with the stated colour. Water bodies are shown in blue or a related water symbol, not yellow, so option (D) is also excluded. The colour is a legend code; it does not imply that every parcel in the zone has already been built on or that all residential development has the same density.

**Step 3:** Conclusion A yellow zone in the master plan denotes residential land use. Hence, the correct option is (A).

**Quick Tip to Solve:** Remember yellow for housing and purple for industry; read map colours as land-use categories rather than as the appearance of actual structures.

**92. In master plan by which color, we show the industrial land use.** [4 marks]

(A) Purple

(B) Grey

(C) Red

(D) Green

**Correct Answer:** (A) Purple

**Solution:**

**Concept:**

- Land-use colours provide a visual legend for a master plan, allowing different activities to be recognised without reading a label on every parcel.
- Industrial use is conventionally represented by purple or violet in the standard planning colour scheme tested here; green usually identifies recreational or open-space uses.

**Step 1:** Recall the industrial colour code An industrial zone accommodates manufacturing and related industrial activities. In the conventional land-use legend used in master-plan questions, the category is assigned purple. Violet is a closely related description of this colour family, but the matching word actually offered in the options is Purple.

**Step 2:** Test each offered colour Option (A), Purple, gives the industrial colour directly. Grey is not the industrial designation in this convention; it can be used for transport or other background categories in map legends. Red is associated with public or semi-public uses in the conventional scheme rather than the industrial category asked about here. Green is associated with parks, recreational land and open spaces, so it is also inconsistent with industrial use. A planning map should always be read with its legend in practice, but this question tests the familiar standard category-colour pairing and provides one clear match.

**Step 3:** Conclusion Industrial land use is shown in purple in the conventional master-plan scheme. Hence, the correct option is (A).

**Quick Tip to Solve:** Pair industrial use with purple or violet, residential use with yellow, and recreation or open space with green when revising standard planning legends.

**93. The book "Image of the City" is written by** [4 marks]

(A) Christopher Alexander

(B) Kevin Lynch

(C) Oxford Newman

(D) Gorden Cullen

**Correct Answer:** (B) Kevin Lynch

**Solution:**

**Concept:**

- The Image of the City is the well-known urban-design book by Kevin Lynch, published in 1960.

- Lynch examined how people perceive, remember and organise the city mentally. His analysis includes paths, edges, districts, nodes and landmarks as elements of the city image.

**Step 1:** Connect the title with its central idea The phrase Image of the City concerns the mental image through which an observer understands an urban environment. Kevin Lynch studied the legibility of cities and the features that help people orient themselves. The association between this book and the five elements of the urban image identifies its author independently of the order of the options.

**Step 2:** Compare the listed authors Kevin Lynch is option (B), so it matches the title. Christopher Alexander is associated with works such as A Pattern Language and with patterns in architecture and design, rather than authorship of this book. The Newman name in the options points to a different urban-design association, defensible space, and not to The Image of the City. Gordon Cullen is associated with townscape and the visual experience of sequences of urban spaces. Although all these themes relate broadly to urban design, that shared field does not make the books interchangeable: the title asked for belongs specifically to Lynch.

**Step 3:** Conclusion The book The Image of the City was written by Kevin Lynch. Hence, the correct option is (B).

**Quick Tip to Solve:** Use the five elements—paths, edges, districts, nodes and landmarks—as a memory link between Kevin Lynch and The Image of the City.

**94. Match List I with List II.**

| List I | List II |
|---|---|
| (A) Carpet Area | (I) Built up area plus proportionate area of common areas |
| (B) Super built up Area | (II) Usable Area |
| (C) Set Back Area | (III) Entire carpet area plus external wall. |
| (D) Plinth Area | (IV) Minimum open space around the building |

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

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

(B) – IV, (B) – II, (C) – I, (D) – III

(C) – II, (B) – I, (C) – IV, (D) – III

(D) – II, (B) – IV, (C) – III, (D) – I

**Correct Answer:** (C) – II, (B) – I, (C) – IV, (D) – III

**Solution:**

**Concept:**

- Carpet area means the usable internal area, while built-up or plinth area includes the building footprint and wall area described in the list.
- Super built-up area adds a proportionate share of common areas to built-up area. A setback is the minimum required open space around the building, rather than an interior floor-area measure.

**Step 1:** Match the four definitions Carpet Area matches Usable Area, so (A) goes with (II). Super

built-up Area matches Built up area plus proportionate area of common areas, giving (B) with (I). Set Back Area is the minimum open space around the building, so (C) matches (IV). Plinth Area matches the description Entire carpet area plus external wall in the supplied list, giving (D) with (III). The distinction is between usable space, the covered building footprint, the addition of common space and the open area required around the footprint.

**Step 2:** Compare the complete code with the options The required sequence is A–II, B–I, C–IV, D–III, which is the third option, labelled (C). The first option interchanges the carpet and plinth descriptions. The second assigns the setback description to carpet area and does not preserve the other definitions. The fourth assigns open space to super built-up area and common-area addition to plinth area. Checking both the straightforward setback match and the area matches prevents selecting a code that gets only one pair right.

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

**Quick Tip to Solve:** Fix setback = open space first; then move from usable carpet area to built-up area and finally add the common-area share for super built-up area.

**95. Match List I with List II.**

| List I | List II |
|---|---|
| (A) Kolkata | (I) Radial |
| (B) Delhi | (II) Linear |
| (C) Chandigarh | (III) Organic |
| (D) Varanasi | (IV) Grid Iron |

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

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

(B) – I, (B) – III, (C) – II, (D) – IV

(C) – II, (B) – I, (C) – IV, (D) – III

(D) – III, (B) – IV, (C) – I, (D) – II

**Correct Answer:** (C) – II, (B) – I, (C) – IV, (D) – III

**Solution:**

**Concept:**

- Urban forms can be classified by their dominant spatial pattern: linear growth follows an axis, radial growth spreads from a centre, and a grid iron uses a regular street network.
- An organic pattern grows incrementally, producing irregular streets and plots rather than a uniform planned grid. These broad categories describe a characteristic urban form, not every street in a city.

**Step 1:** Match the distinctive planned and historic forms Chandigarh is the clearest planned example: its regular sectors and organised road framework correspond to Grid Iron, so (C) matches (IV). Varanasi has an old, incrementally developed urban fabric with narrow and irregular streets, which corresponds to Organic, so (D) matches (III). These two pairs immediately distinguish the correct code from options that assign Chandigarh an organic or linear pattern.

**Step 2:** Complete the remaining pairs and check the code Kolkata is associated in this classification with Linear development, including its elongated growth along the river corridor; hence (A) matches (II). Delhi is matched with Radial, giving (B) with (I). The complete sequence is therefore A–II, B–I, C–IV, D–III. The first option exchanges the distinctive Chandigarh and Varanasi categories. The second does not preserve the linear Kolkata or grid-iron Chandigarh pairs. The fourth assigns still different incompatible forms. Only the third option satisfies all four matches together.

**Step 3:** Conclusion The matching is Kolkata–Linear, Delhi–Radial, Chandigarh–Grid Iron and Varanasi–Organic. Hence, the correct option is (C).

**Quick Tip to Solve:** Anchor Chandigarh to grid-iron sectors and old Varanasi to organic lanes; then check the Kolkata-linear and Delhi-radial pairs in the answer code.

**96. In which year, HRIDAY Launched?** [4 marks]

(A) 2014

(B) 2012

(C) 2015

(D) 2011

**Correct Answer:** (C) 2015

**Solution:**

**Concept:**

- HRIDAY stands for Heritage City Development and Augmentation Yojana, an urban heritage initiative of the Government of India.
- The scheme was launched on 21 January 2015. Its association is with heritage-sensitive city development, including improvement of infrastructure and public spaces in heritage cities.

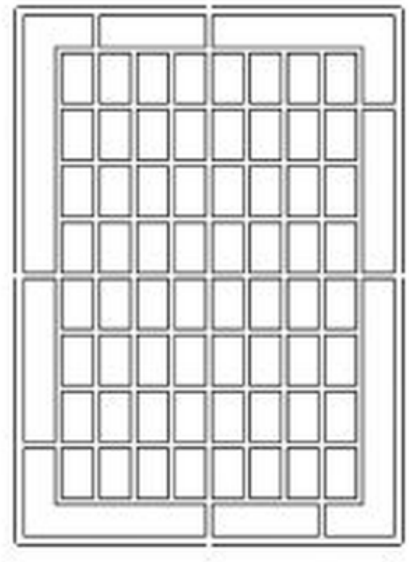
**Step 1:** Identify the scheme before choosing a year The acronym HRIDAY refers to Heritage City Development and Augmentation Yojana. Recognising the full name separates it from other urban missions launched around the same period. It concerns the development and conservation setting of heritage cities, rather than a general rural or industrial programme. The launch year to recall for this particular scheme is 2015.

**Step 2:** Match the date with the four alternatives The launch date, 21 January 2015, places the scheme in the calendar year 2015, which appears as option (C). The year 2014 is earlier than this launch and can be a tempting distractor because several national initiatives are associated with that period. The years 2012 and 2011 also precede the launch of HRIDAY and therefore cannot answer the question. The question asks when the scheme was launched, so the date of a later project completion, allocation or local improvement would not replace the original launch year.

**Step 3:** Conclusion HRIDAY was launched in 2015. Hence, the correct option is (C).

**Quick Tip to Solve:** Expand HRIDAY to Heritage City Development and Augmentation Yojana and attach the date 21 January 2015 to the scheme, rather than to an individual heritage project.

**97. Which type of plan is this?** [4 marks]



(A) Dandaka

(B) Chaturmukha

(C) Padmaka

(D) Karmukha

**Correct Answer:** (B) Chaturmukha

**Solution:**

**Concept:**

- Traditional Indian settlement plans are identified by their overall geometry, street pattern and the arrangement of their approaches, rather than by the number of small plots alone.
- Chaturmukha means four-faced: the plan has approaches on four sides and an orthogonal internal layout. Its straight streets form rectangular blocks within a rectangular boundary.

**Step 1:** Inspect the overall pattern The figure shows a rectangular enclosure filled by two perpendicular families of straight streets. Their intersections divide the settlement into a regular grid of rectangular plots. The boundary is approached through openings associated with the four sides; the design is therefore organised in four directions, rather than along just one dominant linear strip.

**Step 2:** Compare the named plans This rectangular grid with four-sided access is the Chaturmukha pattern. Dandaka is associated with a predominantly linear or staff-like settlement arrangement, so the many cross streets and four-sided organisation do not select it. Padmaka is a lotus-like pattern with a radial or concentric character, which is absent here. Karmukha is bow-shaped or semicircular, whereas the supplied boundary has straight sides and right-angled corners. The outline and access pattern together distinguish the correct name.

**Step 3:** Conclusion The illustrated settlement is a Chaturmukha plan. Hence, the correct option is (B).

**Quick Tip to Solve:** Identify the outer shape and the major approaches first: a rectangular grid organised towards four sides points to Chaturmukha; lotus and bow shapes select different traditional plans.

**98. The roman "FORUM" is also referred as:** [4 marks]

(A) River

(B) Building

(C) Park

(D) Market Place

**Correct Answer:** (D) Market Place

**Solution:**

**Concept:**

- A Roman forum was an open public space at the centre of civic life, accommodating public assembly, exchange and commercial activities.
- The question asks for the closest description among the supplied categories. A forum is a place or urban space, not merely one of the buildings that surrounds it.

**Step 1:** Identify the function of a forum In a Roman town, the forum was the principal public square. People gathered there for civic business, discussion and trading. Public buildings and places of worship often faced this space, but the name forum described the shared public place as a whole. Its commercial function makes market place the relevant description among the four alternatives.

**Step 2:** Eliminate the unrelated categories A river is a natural flowing watercourse and has no connection with the architectural and civic meaning of forum. A building is an enclosed individual structure; although buildings could border a forum, none alone defines the square. A park is primarily an open recreational or landscaped area, which does not capture the characteristic public and commercial role. Market Place is thus the only listed choice matching the historical use. This does not mean that Roman forums had no political or religious functions; it means that the listed market-place description fits the urban space best.

**Step 3:** Conclusion The Roman forum is referred to here as a Market Place. Hence, the correct option is (D).

**Quick Tip to Solve:** For historical urban-space terms, match the main civic or commercial function, and distinguish an open square from the individual buildings around it.

**99. If all the directions are changed in the manner that North becomes South and Vice-Versa, then North-West will be** [4 marks]

(A) South-East

(B) North-East

(C) South-West

(D) North-West

**Correct Answer:** (C) South-West

**Solution:**

**Concept:**

- A diagonal direction combines two perpendicular components: North-West consists of a northward component and a westward component.
- Apply exactly the stated interchange. Here North and South exchange names; no interchange of East and West is stated, so the westward component remains West.

**Step 1:** Transform each component separately Write the original diagonal as North plus West. The specified change sends North to South, and vice versa. It does not say that East becomes West. Therefore the first component changes sign along the north-south axis, while the second component retains its westward designation. The transformed combination is South plus West.

**Step 2:** Match the new direction to the alternatives South combined with West is South-West, option (C). South-East would require the westward component to be changed to East as well, which adds an interchange not given in the question. North-East changes the east-west component and retains North, so it fails both requirements. North-West leaves the northward component unchanged, contrary to the specified reversal. In particular, reversing the north-south labels alone is a reflection of that directional component, not a rotation that automatically reverses both compass axes.

**Step 3:** Conclusion North-West becomes South-West when the stated North/South interchange is applied while West stays West. Hence, the correct option is (C).

**Quick Tip to Solve:** Split a diagonal into its two compass components and change only the components explicitly affected by the given rule; do not automatically reverse both axes.

**100. Inspector Shyam started from Police Station on inspection. After travelling straight for a distance of four (4) KM, he turned left for market and travelled straight 600 meters. He now turned left again and travelled straight for another 200 meters, and turned left and travelled straight for 600 meters. How far is Shyam from Police Station?** [4 marks]

(A) 3.4 Km

(B) 4.8 Km

(C) 3.8 Km

(D) 4.4 Km

**Correct Answer:** (C) 3.8 Km

**Solution:**

**Concept:**

- The distance from the starting point is the magnitude of the final displacement, not the total length of the route travelled.
- After three successive left turns, the second and fourth legs are opposite and parallel; the third leg is opposite to the original direction. Convert all distances to one unit before subtracting.

**Step 1:** Represent the four legs in fixed directions Take the first direction as east without loss of generality. Shyam first goes $4\,\mathrm{km}$ east. His first left turn sends him north for $600\,\mathrm{m} = 0.6\,\mathrm{km}$. The next left turn sends him west for $200\,\mathrm{m} = 0.2\,\mathrm{km}$. The final left turn sends him south for $600\,\mathrm{m} = 0.6\,\mathrm{km}$. Rotating this whole route would not change the required distance.

**Step 2:** Cancel opposite displacements and compare the choices The north and south movements cancel exactly:

$$0.6 - 0.6 = 0.$$

The remaining eastward displacement is

$$4 - 0.2 = 3.8\,\mathrm{km}.$$

Thus he lies on the line of his original movement, short of the first turning point. The choice $3.4\,\mathrm{km}$ incorrectly subtracts one of the sideways legs. The values $4.8\,\mathrm{km}$ and $4.4\,\mathrm{km}$ do not result from cancelling the equal opposite legs. Adding every leg would measure route length, not separation from the police station.

**Step 3:** Conclusion Shyam is $3.8\,\mathrm{km}$ from the Police Station. Hence, the correct option is (C).

**Quick Tip to Solve:** For repeated right-angle turns, record each leg along a fixed pair of axes and cancel opposite movements before finding the separation from the start.

**101. The highest body which approves five year plans of India is:** [4 marks]

(A) Parliament

(B) Planning Commission

(C) Union Cabinet

(D) National Development Council

**Correct Answer:** (D) National Development Council

**Solution:**

**Concept:**

- In the institutional system associated with India's Five Year Plans, preparation of a plan and its final approval were distinct functions.
- The Planning Commission formulated the plans, while the National Development Council was the apex body associated with their approval and with coordination between the Union and the states.

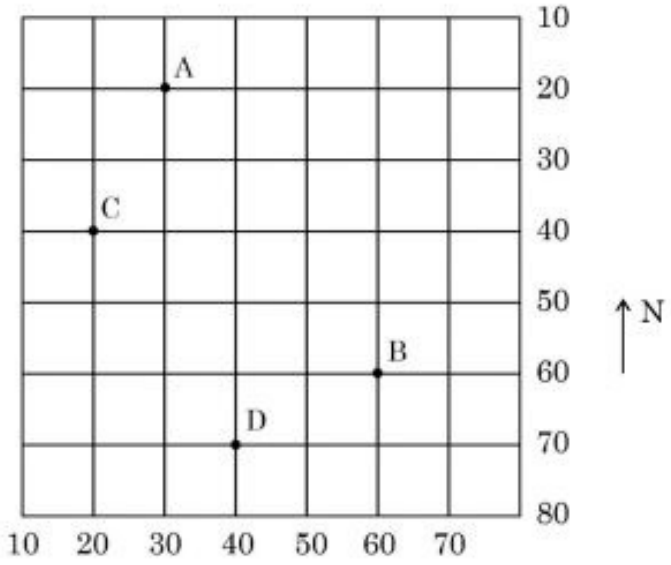
**Step 1:** Identify the approval body in the planning framework The National Development Council brought the national and state leadership together in the development-planning process. Its role included considering and approving Five Year Plans and reviewing their progress. The question refers to the historical Five Year Plan system, so the task is to identify the approving body in that framework rather than to infer a body merely from its general constitutional or executive importance.

**Step 2:** Distinguish the other institutions The Planning Commission prepared and formulated Five Year Plans, but drafting and recommending a plan is not the same as being the highest body approving it. The Union Cabinet had important executive functions, yet the institution conventionally named for final plan approval is the National Development Council. Parliament discusses public policy, authorises expenditure and exercises legislative oversight, but it is not the specified apex plan-approval institution in this question. Therefore the alternatives describing the legislature, the drafting commission and the cabinet do not replace the Council for this particular function.

**Step 3:** Conclusion The highest body approving India's Five Year Plans was the National Development Council. Hence, the correct option is (D).

**Quick Tip to Solve:** Keep the historical roles distinct: Planning Commission formulated the Five Year Plans; National Development Council approved them.

**102. In the given diagram, from A point to C point, how much you have to move** [4 marks]




(A) 20

(B) 30

(C) 10

(D) 40

**Correct Answer:** (B) 30

**Solution:**

**Concept:**

- On the given orthogonal grid, movement follows horizontal and vertical grid lines. The required route length is the sum of the changes along these two directions.
- The numbers increase by 10 between adjacent grid lines. Horizontal coordinates increase to the right, while the row numbers shown on the right increase downwards.

**Step 1:** Read the coordinates of the two points The plotted point A is at the intersection of column $30$ and row $20$, and C is at column $20$ and row $40$. To go from A to C along the grid, one must move one column interval to the left and two row intervals down. The north arrow points upward, so these movements are west and south respectively.

**Step 2:** Add the required horizontal and vertical movements The westward travel is $|30-20| = 10$ grid units and the southward travel is $|40-20| = 20$ grid units. Hence the shortest rectilinear movement on the grid is

$$10 + 20 = 30 \text{ grid units.}$$

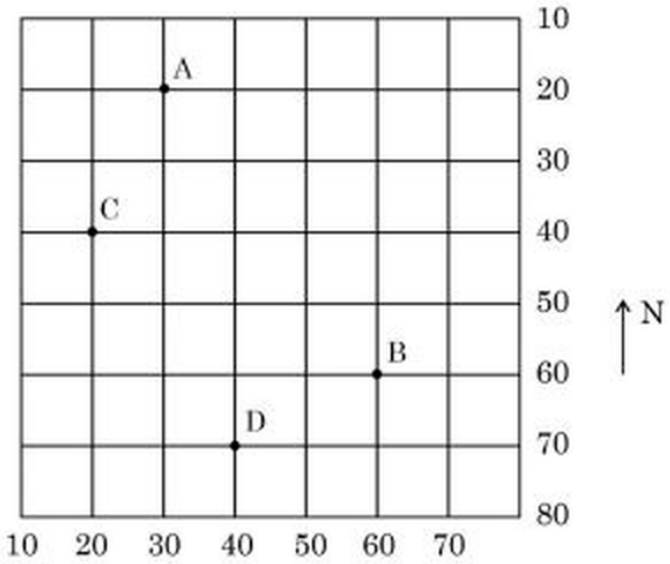
The choices 10 and 20 account for only one of the two necessary components. The choice 40 exceeds the required direct grid route and would require additional travel. This is a grid-movement question: a straight diagonal displacement would be a different measurement, whereas the movement along the horizontal and vertical grid lines gives the listed value 30.

**Step 3:** Conclusion The required movement from A to C along the grid is $30$ grid units. Hence, the

correct option is (B).

**Quick Tip to Solve:** Read both coordinates before counting: for horizontal and vertical grid travel, add the absolute column change and absolute row change.

**103. In the given diagram, from point C to point B, which direction you have to move** [4 marks]




(A) East – North

(B) North – South

(C) South – East

(D) West – South

**Correct Answer:** (C) South – East

**Solution:**

**Concept:**

- The north arrow fixes orientation: upward is North, downward is South, rightward is East and leftward is West.
- To find a diagonal direction between two locations, compare their horizontal positions and then their vertical positions. The row labels here increase downward, so a larger row number is farther south.

**Step 1:** Locate C and B relative to the north arrow Point C lies at column 20, row 40; B lies at column 60, row 60. Thus B is to the right of C because $60 > 20$ in the column coordinates. It is also below C because its row coordinate is 60 rather than 40. With North upward, rightward means East and downward means South.

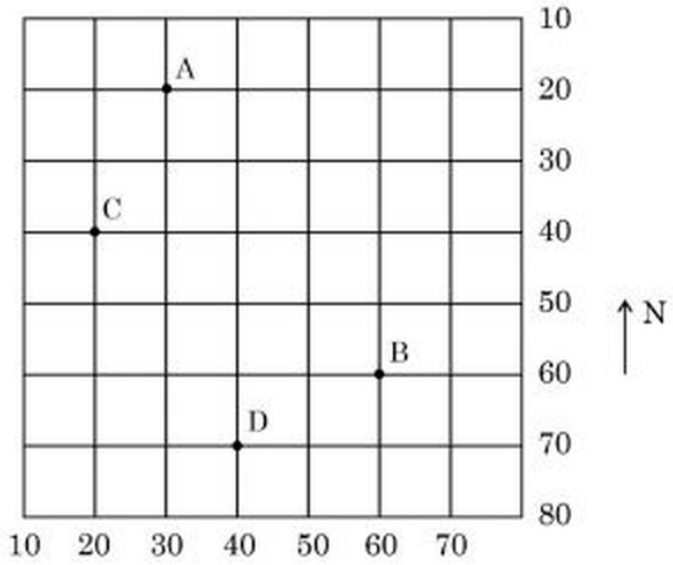
**Step 2:** Combine the two directional components A journey from C towards B therefore has both an eastward and a southward component. This is the South-East direction, matching the wording South – East in option (C). East – North would require B to be above C, which the diagram contradicts. North

– South describes opposing vertical directions and does not represent the clear eastward component. West – South gives the correct vertical sense but the wrong horizontal sense, since B is on the right, not on the left, of C. The two components need not have equal magnitudes for B to lie generally to the south-east of C.

**Step 3:** Conclusion From C towards B, move in the South-East direction. Hence, the correct option is (C).

**Quick Tip to Solve:** Use the printed north arrow before interpreting coordinate numbers: on this map, increasing row labels mean movement south, not north.

**104. With the reference to the diagram, choose the correct statement.** [4 marks]




(A) The distance from B to D is 20

(B) The distance from B to D is 10

(C) The distance from B to C is 10

(D) The distance from B to D is 30

**Correct Answer:** (D) The distance from B to D is 30

**Solution:**

**Concept:**

- The grid uses a spacing of 10 units between successive labelled lines. For travel along its horizontal and vertical lines, add the absolute horizontal and vertical coordinate differences.
- Coordinates identify the two movement components separately. Counting only one component underestimates the route whenever the two points are neither on the same row nor on the same column.

**Step 1:** Calculate the grid distance between B and D B is at column 60, row 60, and D is at column 40, row 70. From B to D, the route must cover two intervals west and one interval south. These

components have lengths

$$|60 - 40| = 20, \qquad |70 - 60| = 10.$$

Their sum gives the direct rectilinear grid-route distance:

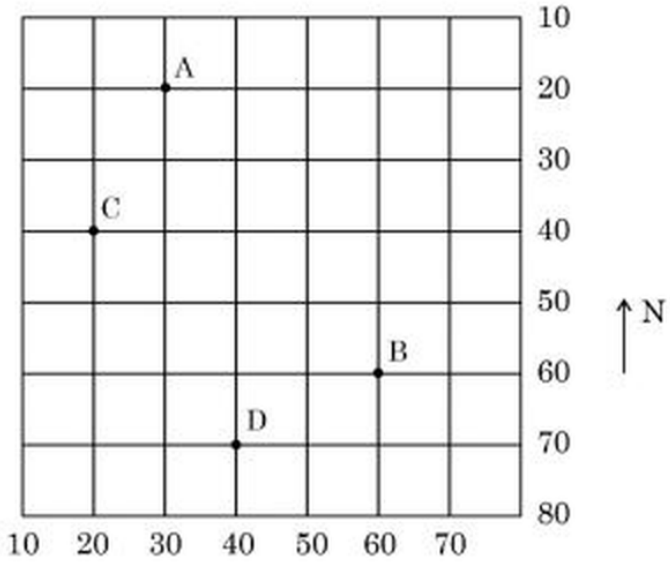
$$BD = 20 + 10 = 30 \text{ grid units.}$$

**Step 2:** Check every statement against the grid Option (A), which gives 20 for B to D, includes only the horizontal component; option (B), which gives 10, includes only the vertical component. For option (C), C is at $(20, 40)$, so movement between B and C requires $|60-20|+|60-40| = 40+20 = 60$ grid units, not 10. Option (D) correctly gives 30 for the route from B to D. Here distance is being read as movement along the grid lines, consistent with the accompanying map-movement questions; a straight diagonal separation is a different quantity.

**Step 3:** Conclusion The correct statement is that the grid-route distance from B to D is 30. Hence, the correct option is (D).

**Quick Tip to Solve:** Test grid-distance statements by adding both coordinate differences; a distractor often gives just the horizontal or just the vertical component.

**105. In the given diagram, northern most point is** [4 marks]




(A) C only

(B) D only

(C) B only

(D) A only

**Correct Answer:** (D) A only

**Solution:**

**Concept:**

- The north arrow establishes the orientation of a map. Here it points vertically upwards, so moving upwards on the grid means moving northwards.
- The northernmost point is the one furthest in the north-arrow direction. Its horizontal position does not affect this comparison; eastward and westward displacement are separate from northward displacement.

**Step 1:** Establish the direction of north Read the arrow marked N to the right of the grid. It points towards the top of the diagram. Therefore, compare the vertical positions of A, B, C and D, rather than their distances from the left edge or the numerical sizes of their horizontal coordinates.

**Step 2:** Compare the four horizontal grid lines A lies on the horizontal line labelled 20 at the right. C lies on the line labelled 40, B on the line labelled 60, and D on the line labelled 70. These right-hand labels increase downwards in this particular diagram. Thus the smaller label corresponds to the higher position, and A lies above C, B and D. The order from north to south is A, C, B, D.

**Step 3:** Check each offered answer C only is incorrect because A is above C. D only is incorrect because D is the lowest of the four marked points. B only is incorrect because both A and C are above B. A only is correct because no other marked point is on A's horizontal line or farther upwards. The word "only" is appropriate: the northernmost position is unique among the four choices.

**Step 4:** Conclusion A is the northernmost point, since it is furthest in the direction of the upward north arrow. Hence, the correct option is (D).

**Quick Tip to Solve:** Follow the north arrow before comparing coordinates: when grid labels increase downwards, the largest vertical label identifies a more southerly point, not a more northerly one.