

GATE 2023 Geomatics Engineering (GE) Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :100	Total questions :84
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General Aptitude (GA)

Q.1 “You are delaying the completion of the task. Send _____ contributions at the earliest.”

(A) you are

(B) your

(C) you’re

(D) yore

Correct Answer: (B) your

Solution:

1) Slot test (what kind of word fits before a plural noun?).

The blank precedes the plural count noun “contributions.” In English noun phrases, this position is typically filled by a *determiner* (e.g., *the, some, my, your*) that specifies the noun. Therefore, we need a determiner. “**Your**” is the second-person possessive determiner and fits perfectly: “*Send your contributions . . .*”

2) Grammatical form and function of each option.

(A) you are: a finite verb phrase (subject + auxiliary), not a determiner; it cannot directly modify a noun. “*Send you are contributions*” is ungrammatical.

(B) your: possessive determiner; it modifies a following noun to indicate possession/association (*your report, your files*). Grammatically correct and semantically intended: the contributions that belong to the addressee.

(C) you’re: contraction of “you are.” Like (A), it is verbal (*you are*), not determinative. “*Send you’re contributions*” is ungrammatical because a verb phrase cannot function as a determiner.

(D) yore: a noun meaning “long ago” (as in *days of yore*); unrelated in meaning and cannot serve as a determiner before “contributions.”

3) Agreement and idiom.

The idiomatic business/academic request is “*Send your contributions at the earliest.*” Here “your” correctly signals that the sender expects submissions from the recipient(s). Any verbal form (“you are”/“you’re”) would require a complement clause, not a noun: e.g., “*You’re delaying ... ; send your contributions ...*” (two separate clauses).

4) Quick diagnostics (try substitutions).

Replace the noun with another plural noun: “*Send your documents / your comments.*” These remain correct. Try with (A)/(C): “*Send you are documents*” or “*Send you’re documents*” — clearly incorrect.

The only grammatical and meaningful choice is (B) your.

Quick Tip

your = possessive determiner before a noun (*your idea*).

you’re = *you are* (verb phrase), never used directly before a noun.

yore = “long ago,” a separate noun used in the phrase *of yore*.

Q.2 References : _____ : : Guidelines : Implement

(By word meaning)

(A) Sight

(B) Site

(C) Cite

(D) Plagiarise

Correct Answer: (C) Cite

Solution:

1) Identify the relation in the second pair.

“Guidelines : Implement” expresses an *object* → *appropriate action* relation. The noun “guidelines” is something that you *implement*. So we look for a verb that is the correct action you perform on “references.”

2) Collocation/usage test for each option.

(A) *Sight*: “Sight” is primarily a noun (vision) and as a verb means “to see/spot” (e.g., “to sight land”). We do not “sight references” in academic or professional English.

(B) *Site*: Homophone of “cite”, but “site” is a noun meaning “location/place,” or a verb meaning “to place/locate.” “To site references” is incorrect. This option is a common trap based on sound-alike words.

(C) *Cite*: Verb meaning “to quote/mention as evidence or authority; to reference explicitly in a text.” In writing, we *cite references*. This perfectly mirrors “implement guidelines.”

(D) *Plagiarise*: Verb meaning “to copy another’s work/ideas and pass them off as one’s own.” This is the *opposite* of proper use of references; you *avoid* plagiarising when you *cite* references. Hence not the intended action.

3) Part-of-speech parallelism.

The pair should keep the same parts of speech: *Noun* : *Verb*. “Guidelines : Implement” (*Noun* : *Verb*) ⇒ we need a verb for “References : ____.” Only *cite* fits both meaning and grammar naturally.

4) Final mapping.

References : **Cite** :: Guidelines : **Implement**

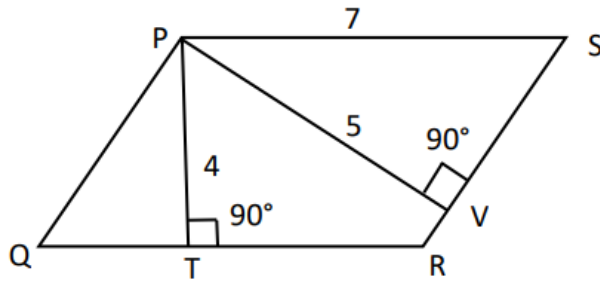
Both pairs express “perform the correct action on the given object.”

(C) Cite

Quick Tip

In analogy questions, first pin down the *relation type* (here, object → appropriate action) and enforce *part-of-speech parallelism*. Beware homophones: **cite** (quote/mention), **site** (location), **sight** (see/vision). Only “*cite references*” is correct usage.

Q.3 In the given figure, PQRS is a parallelogram with $PS = 7$ cm, $PT = 4$ cm and $PV = 5$ cm. What is the length of RS in cm? (The diagram is representative.)



- (A) $\frac{20}{7}$
 (B) $\frac{28}{5}$
 (C) $\frac{9}{2}$
 (D) $\frac{35}{4}$

Correct Answer: (B) $\frac{28}{5}$

Very Detailed Solution:

Key facts about a parallelogram.

- Opposite sides are parallel: $PS \parallel QR$ and $PQ \parallel RS$.
- The *area* of a parallelogram is “base $\times$ corresponding altitude” and is independent of which side you pick as the base.
- The altitude to a base is the perpendicular distance between the two lines containing a pair of opposite sides that are parallel to that base.

What the given perpendiculars represent.

- $PT \perp QR$ with $PT = 4$. Since $PS \parallel QR$, the perpendicular distance from *any* point on PS to the line QR equals the altitude corresponding to the base PS . Thus, PT is the altitude to base PS .
- $PV \perp RS$ with $PV = 5$. Since $PQ \parallel RS$, the perpendicular distance from *any* point on PQ to the line RS equals the altitude corresponding to the base RS . Thus, PV is the altitude to base RS .

Compute the area two ways.

$$\text{Area} = (\text{base } PS) \times (\text{altitude to } PS) = 7 \times 4 = 28 \text{ cm}^2.$$

Using RS as the base:

$$\text{Area} = (\text{base } RS) \times (\text{altitude to } RS) = RS \times 5.$$

Equate the two area expressions:

$$RS \times 5 = 28 \quad \Rightarrow \quad RS = \frac{28}{5} \text{ cm}.$$

(Alternative coordinate/vector check.) Place QR on the x -axis with $Q = (0, 0)$ and $R = (7, 0)$ (since $QR \equiv PS$ and $PS = 7$). Let $P = (x_0, 4)$ so that $PT = 4$. Then $S = P + (R - Q) = (x_0 + 7, 4)$; the side RS has direction vector $S - R = (x_0, 4)$ and length

$$|RS| = \sqrt{x_0^2 + 4^2}.$$

The area of the parallelogram is also $|QR| \times (\text{vertical separation between the parallels } QR \text{ and } PS) = 7 \times 4 = 28$. Using base RS , the perpendicular distance to its opposite side is $PV = 5$, hence area $= |RS| \cdot 5$. Therefore $|RS| = 28/5$, independent of x_0 , confirming the earlier result.

$$RS = \frac{28}{5} \text{ cm}$$

Quick Tip

In a parallelogram, if two perpendicular distances to two different sides are given, equate the two area formulas:

$$(\text{known side}) \times (\text{its altitude}) = (\text{unknown side}) \times (\text{its altitude}).$$

This avoids trigonometry or coordinates.

Q.4 In 2022, June Huh was awarded the Fields medal, which is the highest prize in Mathematics.

When he was younger, he was also a poet. He did not win any medals in the International Mathematics Olympiads. He dropped out of college.
Based only on the above information, which one of the following statements can be logically inferred with certainty?

- (A) Every Fields medalist has won a medal in an International Mathematics Olympiad.
- (B) Everyone who has dropped out of college has won the Fields medal.
- (C) All Fields medalists are part-time poets.
- (D) Some Fields medalists have dropped out of college.

Correct Answer: (D)

Let the universe be “all people.” Define predicates:

$F(x)$: “ x is a Fields medalist.”

$M(x)$: “ x has won an International Mathematics Olympiad medal.”

$P(x)$: “ x is a poet.”

$D(x)$: “ x has dropped out of college.”

Let j denote June Huh. From the passage we have the facts:

- 1) $F(j)$ (June Huh is a Fields medalist.)
- 2) $\neg M(j)$ (He did not win any IMO medals.)
- 3) $D(j)$ (He dropped out of college.)
- 4) $P(j)$ (He was also a poet.)

Now evaluate each option using these facts alone.

Option (A): “Every Fields medalist has won an IMO medal.”

Formal form: $\forall x (F(x) \Rightarrow M(x))$.

A single counterexample falsifies a universal statement. We know $F(j)$ and $\neg M(j)$, hence j is a counterexample.

Therefore (A) is **False**.

Option (B): “Everyone who has dropped out of college has won the Fields medal.”

Formal form: $\forall x (D(x) \Rightarrow F(x))$.

From the passage we only know $D(j)$ and $F(j)$ for one person. This does *not* justify a universal rule about *all* dropouts.

Construct a model consistent with the passage but making (B) false: add a person u with $D(u)$ and $\neg F(u)$. None of the given facts mention u , so the passage remains true while (B) fails.

Hence (B) cannot be inferred; it is **Not entailed**.

Option (C): “All Fields medalists are part-time poets.”

Formal form: $\forall x (F(x) \Rightarrow P(x))$.

Again, one instance $F(j) \wedge P(j)$ is insufficient to conclude a universal rule. We can conceive a person v with $F(v)$ and $\neg P(v)$ without contradicting any given fact.

Therefore (C) is **Not entailed**.

Option (D): “Some Fields medalists have dropped out of college.”

Formal form: $\exists x (F(x) \wedge D(x))$.

This is an existential statement and is *directly* witnessed by $x = j$ since $F(j)$ and $D(j)$ are both true. No additional assumptions are needed.

Therefore (D) is **Certainly True**.

Key logical lesson:

- Universal claims ($\forall$) require evidence about *all* members; a single counterexample suffices to refute them.
- Existential claims ($\exists$) require evidence about *at least one* member; a single confirmed instance proves them.
- The passage gives one concrete instance (June Huh) with properties F , D , $\neg M$, P . Thus only the existential statement in (D) is logically forced by the data.

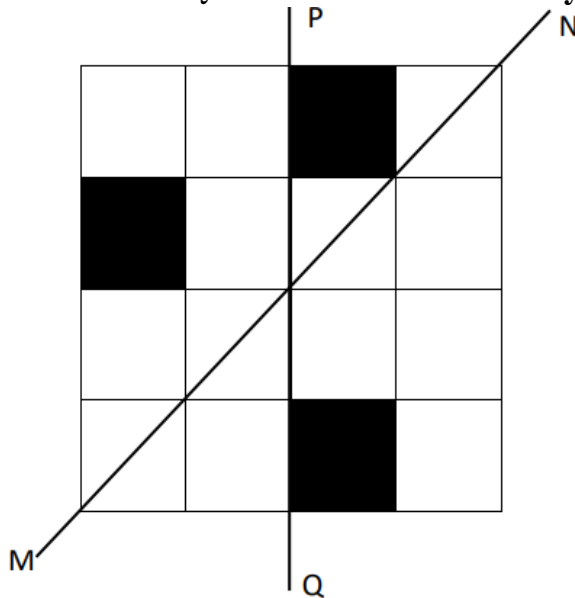
(D) Some Fields medalists have dropped out of college.

Quick Tip

Translate options into quantifiers: “Every/All” $\rightarrow \forall$, “Some” $\rightarrow \exists$. Check if the passage provides a counterexample (to kill $\forall$) or a witness (to prove $\exists$).

Q.5 A line of symmetry is defined as a line that divides a figure into two parts in a way such that each part is a mirror image of the other part about that line.

The given figure consists of 16 unit squares arranged as shown. In addition to the three black squares, what is the minimum number of squares that must be coloured black, such that both PQ and MN form lines of symmetry? (The figure is representative)



- (A) 3
- (B) 4
- (C) 5
- (D) 6

Correct Answer: (C) 5

Solution:

Label the 4×4 grid cells by coordinates (x, y) with $x = 1, 2, 3, 4$ from left to right and $y = 1, 2, 3, 4$ from bottom to top.

From the figure, the initially black squares are $(3, 4)$ (top row, third column), $(1, 3)$ (second row, first column), and $(3, 1)$ (bottom row, third column).

Symmetry conditions:

- Reflection about the vertical midline PQ maps $(x, y) \mapsto (5 - x, y)$.
- Reflection about the diagonal MN (the line $y = x$) maps $(x, y) \mapsto (y, x)$.

Close the set under both reflections (and hence under their composition).

Start with $S = \{(3, 4), (1, 3), (3, 1)\}$.

Apply PQ : $(3, 4) \rightarrow (2, 4)$, $(1, 3) \rightarrow (4, 3)$, $(3, 1) \rightarrow (2, 1)$, so add $\{(2, 4), (4, 3), (2, 1)\}$.

Apply MN : $(2, 4) \rightarrow (4, 2)$ and $(2, 1) \rightarrow (1, 2)$; the images of $(3, 4)$, $(1, 3)$, $(3, 1)$, $(4, 3)$ are already in S . Add $\{(4, 2), (1, 2)\}$.

Applying the reflections again yields no new cells (closure reached).

Final symmetric set:

$\{(3, 4), (2, 4), (4, 3), (1, 3), (4, 2), (1, 2), (3, 1), (2, 1)\}$ — a total of 8 squares.

Since 3 were already black, the *minimum additional* squares needed $= 8 - 3 = 5$.

5

Quick Tip

When a figure must be symmetric about two lines, take the “orbit” of each marked cell under both reflections (and their composition). The minimal coloring is the union of these orbits.

Q.6 Human beings are one among many creatures that inhabit an imagined world. In this imagined world, some creatures are cruel. If in this imagined world, it is given that the statement “Some human beings are not cruel creatures” is FALSE, then which of the following set of statement(s) can be logically inferred with certainty?

- (i) All human beings are cruel creatures.
- (ii) Some human beings are cruel creatures.
- (iii) Some creatures that are cruel are human beings.
- (iv) No human beings are cruel creatures.

- (A) only (i)
- (B) only (iii) and (iv)
- (C) only (i) and (ii)
- (D) (i), (ii) and (iii)

Correct Answer: (D) (i), (ii) and (iii)

Solution:

Let H = set of human beings, C = set of cruel creatures. The given false statement is

$$\text{“Some human beings are not cruel”} \equiv \exists x (x \in H \wedge x \notin C).$$

Its being *false* means the negation is *true*:

$$\neg \exists x (x \in H \wedge x \notin C) \equiv \forall x (x \in H \Rightarrow x \in C).$$

Hence $H \subseteq C$. Also, the stem explicitly implies humans exist (“Human beings are one among many creatures that inhabit the world”). Finally, we are told $\exists$ cruel creatures (“some creatures are cruel”). Now test each claim:

(i) All human beings are cruel creatures. This is precisely $\forall x (x \in H \Rightarrow x \in C)$. $\Rightarrow$ **True.**

(ii) Some human beings are cruel creatures. Since $H \neq \emptyset$ (humans inhabit the world) and $H \subseteq C$, there exists at least one $h \in H \cap C$. $\Rightarrow$ **True.**

(iii) Some creatures that are cruel are human beings. From (ii), the witness h is both human and cruel, hence $C \cap H \neq \emptyset$. $\Rightarrow$ **True.**

(iv) No human beings are cruel creatures. This would be $H \cap C = \emptyset$, contradicting (ii)/(iii). $\Rightarrow$ **False.**

Therefore, exactly **(i), (ii), (iii)** follow with certainty.

Answer: (D)

Quick Tip

When a statement of the form “Some A are not B ” is **false**, its negation “ $\forall x \in A, x \in B$ ” is **true**. Combine this with existence (does A actually contain anything?) to decide “some A are B ” and related claims.

Q.7 To construct a wall, sand and cement are mixed in the ratio of 3:1. The cost of sand and that of cement are in the ratio of 1:2.

If the total cost of sand and cement to construct the wall is 1000 rupees, then what is the cost (in rupees) of cement used?

- (A) 400
- (B) 600
- (C) 800
- (D) 200

Correct Answer: (A)

Solution:

Let unit costs be $c_s : c_c = 1 : 2$. Quantities mixed are $q_s : q_c = 3 : 1$. Cost share $\propto$ (quantity) $\times$ (unit cost). Hence

$$\text{Sand share} : \text{Cement share} = (3 \times 1) : (1 \times 2) = 3 : 2.$$

Total cost is 1000, so cement's part is

$$\frac{2}{3 + 2} \times 1000 = \frac{2}{5} \times 1000 = 400.$$

400

Quick Tip

When items are mixed in a ratio and have different unit costs, allocate total cost using “quantity $\times$ unit-cost” as weights.

Q.8 The World Bank has declared that it does not plan to offer new financing to Sri Lanka, which is battling its worst economic crisis in decades, until the country has an adequate macroeconomic policy framework in place. In a statement, the World Bank said Sri Lanka needed to adopt structural reforms that focus on economic stabilisation and tackle the root causes of its crisis. The latter has starved it of foreign exchange and led to shortages of food, fuel, and medicines. The bank is repurposing resources under

existing loans to help alleviate shortages of essential items such as medicine, cooking gas, fertiliser, meals for children, and cash for vulnerable households.

Based only on the above passage, which one of the following statements can be inferred with certainty?

(A) According to the World Bank, the root cause of Sri Lanka's economic crisis is that it does not have enough foreign exchange.

(B) The World Bank has stated that it will advise the Sri Lankan government about how to tackle the root causes of its economic crisis.

(C) According to the World Bank, Sri Lanka does not yet have an adequate macroeconomic policy framework.

(D) The World Bank has stated that it will provide Sri Lanka with additional funds for essentials such as food, fuel, and medicines.

Correct Answer: (C)

Why (C) is certain.

The first sentence says the Bank “*does not plan to offer new financing . . . until the country has an adequate macroeconomic policy framework in place.*” This implies the required framework is *not yet in place*. Therefore it follows with certainty that, according to the World Bank, Sri Lanka *does not yet have* an adequate macroeconomic policy framework.

Why the others are not entailed.

(A) The passage distinguishes between *root causes* and their *effects*: it says the crisis “has starved it of foreign exchange. . .”. So, lack of foreign exchange is presented as a consequence, not *the* root cause. Hence (A) overstates.

(B) The Bank “said Sri Lanka needed to adopt structural reforms” (a recommendation), but it never states it *will advise* the government (an explicit future action/engagement). Not guaranteed.

(D) The Bank is *repurposing resources under existing loans*—not providing *additional* (new) funds. Thus (D) contradicts the stated “does not plan to offer new financing.”

Therefore, only (C) follows with certainty.

Quick Tip

In inference questions, watch for words that signal necessity or timing (“until”, “does not plan to”) and distinguish *causes* from *effects*. Also, “repurposing existing funds” $\neq$ “providing additional funds.”

Q.9 The coefficient of x^4 in the polynomial $(x - 1)^3(x - 2)^3$ is equal to

- (A) 33
- (B) -3
- (C) 30
- (D) 21

Correct Answer: (A) 33

Solution:

Expand each cubic: $(x - 1)^3 = x^3 - 3x^2 + 3x - 1$, $(x - 2)^3 = x^3 - 6x^2 + 12x - 8$.

Let $A(x) = \sum_{i=0}^3 a_i x^i$ with $(a_0, a_1, a_2, a_3) = (-1, 3, -3, 1)$, and $B(x) = \sum_{j=0}^3 b_j x^j$ with $(b_0, b_1, b_2, b_3) = (-8, 12, -6, 1)$.

In the product $A(x)B(x)$, the coefficient of x^4 is $\sum_{i+j=4} a_i b_j = a_1 b_3 + a_2 b_2 + a_3 b_1$.

Compute: $a_1 b_3 = 3 \cdot 1 = 3$, $a_2 b_2 = (-3) \cdot (-6) = 18$, $a_3 b_1 = 1 \cdot 12 = 12$.

Sum: $3 + 18 + 12 = 33$.

33

Quick Tip

To get a specific coefficient in a product, convolve the coefficients: only pairs whose degrees add to the target degree contribute.

Q.10 Which one of the following shapes can be used to tile (completely cover by repeating) a flat plane, extending to infinity in all directions, without leaving any empty spaces in between them? The copies of the shape used to tile are identical and are not allowed to overlap.

- (A) circle
- (B) regular octagon
- (C) regular pentagon
- (D) rhombus

Correct Answer: (D) rhombus

Solution:

A shape tiles the plane if copies meet edge-to-edge with interior angles around every vertex summing to 360° .

- **Circle:** cannot tile because curved boundaries leave gaps unless stretched/overlapped. **No.**
- **Regular octagon:** interior angle = 135° ; $360/135 = 2.666 \dots$ is not an integer, so identical regular octagons alone cannot fill the plane (they need squares). **No.**
- **Regular pentagon:** interior angle = 108° ; $360/108 = 3.\bar{3}$ not an integer; identical regular pentagons cannot tile the plane. **No.**
- **Rhombus** (any parallelogram with equal sides): opposite angles are equal and adjacent angles sum to 180° ; two copies meet to make 360° around each vertex via translations. All parallelograms, hence rhombi, tile the plane. **Yes.**

Rhombus tiles the plane

Quick Tip

For regular n -gons to tile alone, the interior angle $\frac{(n-2)180^\circ}{n}$ must divide 360° . Only $n = 3, 4, 6$ work. Parallelograms (including rhombi) always tile by translation.

Q.11 An angle was measured with a standard error of 5". How many observations a surveyor needs to take in order to obtain a standard error of 1" for the mean value of this angle?

- (A) 5
- (B) 1
- (C) 10
- (D) 25

Correct Answer: (D) 25

Solution:

Standard error (SE) of the mean: If each observation has standard deviation σ , then for n i.i.d. observations, the SE of the sample mean is $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$.

Here the single-observation standard error is 5" (acts as σ). We require $\sigma_{\bar{x}} = 1''$. Hence

$$\frac{5''}{\sqrt{n}} = 1'' \Rightarrow \sqrt{n} = 5 \Rightarrow n = 25.$$

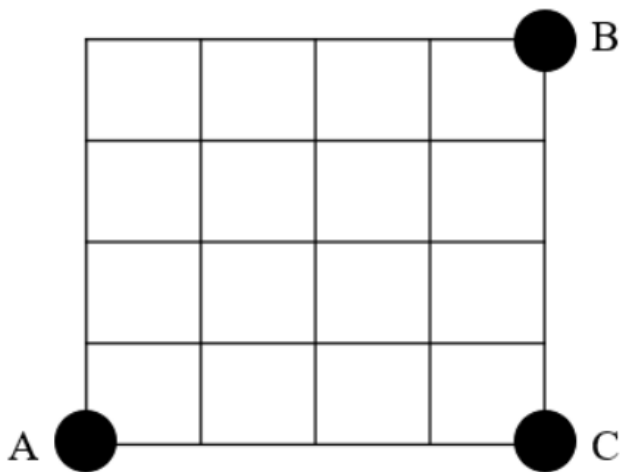
Therefore, the surveyor must take **25** observations.

25

Quick Tip

Averaging n independent measurements reduces random error by $\sqrt{n}$. To improve precision by a factor k , you need $n = k^2$ observations.

Q.12 What are the Manhattan and Pythagorean distances (in m), respectively between points A and B in the figure below, where the Euclidean distance between A and C is 4 m, and the Euclidean distance between C and B is 4 m? All the cells have the same edge lengths.



- (A) 9.0 and 5.7
- (B) 5.7 and 8.0
- (C) 5.7 and 5.7
- (D) 8.0 and 5.7

Correct Answer: (D) 8.0 and 5.7

Solution:

From the figure, A and C are opposite corners of the bottom side and C and B are opposite corners of the right side; both side lengths are 4 m. Hence the square has side 4 m.

Manhattan distance $d_M(A, B)$: sum of axis-aligned displacements $\Rightarrow 4 + 4 = 8$ m.

Pythagorean (Euclidean) distance $d_E(A, B)$: diagonal of a 4×4 square

$\Rightarrow \sqrt{4^2 + 4^2} = 4\sqrt{2} \approx 5.656 \approx 5.7$ m (to one decimal).

$$d_M = 8.0 \text{ m}, \quad d_E \approx 5.7 \text{ m}$$

Quick Tip

On grids, Manhattan distance is the ℓ_1 norm (sum of horizontal and vertical moves).
The straight-line distance is the ℓ_2 norm via Pythagoras: $\sqrt{\Delta x^2 + \Delta y^2}$.

Q.13 Which of the following is tested using the Chi-square test in least squares adjustment?

- (A) Adjusted and observed values of observations are statistically similar
- (B) Presence of gross errors in observations
- (C) Adjusted and assumed values of parameters are statistically similar
- (D) High correlation between observations and residuals

Correct Answer: (B)

Solution:

In least-squares adjustment, the χ^2 (global model) test checks the *stochastic model* by comparing the observed variance factor $\hat{\sigma}_0^2$ (from residuals) with the a priori variance factor σ_0^2 via

$$\chi^2 = \frac{v^\top P v}{\sigma_0^2} \quad \text{with } \chi_{\nu, \alpha}^2 \text{ bounds, } \nu = \text{dof.}$$

If the statistic lies outside the acceptance region, the model is rejected—typically indicating *gross errors/blunders* or an incorrect noise model. Hence, it is used to test for the **presence of gross errors**.

Quick Tip

χ^2 test is a *global* check (whole network); identifying which observation is bad needs *local* tests (e.g., Baarda data snooping or t-tests on normalized residuals).

Q.14 In active remote sensing of Earth objects from a satellite-borne sensor, the source of the energy used for sensing, lies at the _____.

- (A) satellite
- (B) Sun
- (C) object being sensed on Earth
- (D) ground station

Correct Answer: (A)

Solution:

Active sensors (e.g., SAR, LiDAR, radar altimeters) *transmit* their own electromagnetic energy and measure the backscattered signal. When the sensor is satellite-borne, the

transmitter—and therefore the energy source—resides on the **satellite**. Passive sensors, in contrast, rely on external sources such as the Sun or Earth's thermal emission.

Quick Tip

Active = sensor emits (source on the platform). Passive = sensor listens (source external, typically the Sun or thermal Earth).

Q.15 For a push-broom sensor, the following details are given:

Number of detectors = 3000

Height above the ground = 900 km

Swath on the ground = 30 km

The spatial resolution of the sensor is _____ m.

- (A) 30
- (B) 270
- (C) 3
- (D) 10

Correct Answer: (D) 10

Idea: In a push-broom sensor, one line on the ground is imaged at a time by an array of N detectors. The ground-projected width (GSD) per detector equals total swath divided by the number of detectors.

Compute spatial resolution (GSD).

Swath = 30 km = 30,000 m, $N = 3000$.

$$\text{GSD} = \frac{30,000 \text{ m}}{3000} = 10 \text{ m.}$$

10 m

Quick Tip

For push-broom scanners, spatial resolution $\approx \frac{\text{swath}}{\text{number of detectors}}$. Height affects IFOV design but not the simple swath/array GSD relation when swath is already specified.

Q.16 To visually distinguish between a river channel and a canal on an image, having similar widths and located in the same area, the most important parameter used is _____.

- (A) size
- (B) shape
- (C) tone
- (D) texture

Correct Answer: (B) shape

Visual interpretation keys include tone/color, texture, shape, size, pattern, shadow, site, and association. For river vs canal with similar widths and in the same area:

- **Rivers** are typically *sinuous/meandering*, branching, with irregular planform.
- **Canals** are *straight or regularly aligned* and engineered, often with right-angle turns or uniform alignment.

When tone and size are comparable, the **shape** (planform geometry) is the most discriminative cue.

shape

Quick Tip

When interpreting man-made vs natural linear water features: use **shape/pattern**. Man-made features tend to be straight/regular; natural ones are meandering/irregular.

Q.17 The unit of spectral radiance is

- (A) $\text{W sr}^{-1} \mu\text{m}^{-1}$
- (B) $\text{W m}^{-2} \text{sr}^{-1}$
- (C) W m^{-2}
- (D) $\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$

Correct Answer: (D) $\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$

Solution:

Spectral radiance L_λ is the radiant power *per unit projected area, per unit solid angle, and per unit wavelength*.

Therefore the unit is power divided by area, solid angle, and wavelength interval:

$$\text{W}/(\text{m}^2 \cdot \text{sr} \cdot \mu\text{m}) = \text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}.$$

Quick Tip

Radiance $\Rightarrow$ area & direction & spectrum all at once:

Irradiance E : W m^{-2} (no sr, no spectral term).

Radiant intensity I : W sr^{-1} (no area, no spectral term).

Spectral radiance L_λ : $\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$.

Q.18 The ratio between the reflected to the incident energy on a surface at a particular wavelength gives the of the surface.

- (A) spectral reflectance
- (B) spectral transmittance
- (C) spectral radiance
- (D) spectral irradiance

Correct Answer: (A) spectral reflectance

Solution:

At wavelength λ , spectral reflectance ρ_λ is defined as

$$\rho_\lambda = \frac{\text{reflected radiant energy (or flux) at } \lambda}{\text{incident radiant energy (or flux) at } \lambda}.$$

Spectral transmittance τ_λ uses transmitted energy in the numerator; spectral irradiance E_λ is incident power per unit area per unit wavelength; spectral radiance L_λ is power per unit area–solid-angle–wavelength. Hence the ratio asked is **spectral reflectance**.

Quick Tip

Think “R–T–A” at each wavelength: ρ_λ (reflect), τ_λ (transmit), α_λ (absorb) with $\rho_\lambda + \tau_\lambda + \alpha_\lambda = 1$ (for non-emitting, non-lasing samples).

Q.19 GNSS stands for Global Navigation Satellite Systems. As of today, which of the following is the complete set of GNSS constellations that cover the entire globe?

- (A) GPS, GLONASS, Galileo, BeiDou, IRNSS, QZSS
- (B) GPS, GLONASS, Galileo, BeiDou, IRNSS, QZSS, GAGAN, WAAS, EGNOS
- (C) GPS, GLONASS, Galileo
- (D) GPS, GLONASS, Galileo, BeiDou

Correct Answer: (D) GPS, GLONASS, Galileo, BeiDou

Solution:

A *GNSS constellation that covers the entire globe* is a stand-alone satellite navigation system with worldwide service. As of today, the four such constellations are: **GPS** (USA), **GLONASS** (Russia), **Galileo** (EU), and **BeiDou** (China).

IRNSS/NavIC (India) and **QZSS** (Japan) are *regional* systems (coverage over specific regions, not global). **GAGAN**, **WAAS**, and **EGNOS** are *SBAS augmentations*, not core constellations. Hence only option (D) lists the complete set of globally covering constellations.

(D)

Quick Tip

Global GNSS constellations: **GPS, GLONASS, Galileo, BeiDou**. Regional systems: **NavIC/IRNSS, QZSS**. SBAS (WAAS/EGNOS/GAGAN) *augment* GNSS but are not themselves global constellations.

Q.20 The basic premise for using the DGPS technique is to reduce the errors due to

- (A) atmosphere, satellite orbit, multipath
- (B) atmosphere, satellite orbit, satellite clock
- (C) atmosphere, satellite clock, receiver clock
- (D) atmosphere, satellite orbit, satellite clock, receiver clock, multipath

Correct Answer: (B) atmosphere, satellite orbit, satellite clock

Solution:

Differential GPS (DGPS) uses a reference receiver at a *known* location to estimate range errors for each satellite and broadcast corrections to nearby rovers. Because the base and rover are close, several errors are *common-mode* and hence removable:

- **Atmospheric delays** (ionosphere and troposphere) — largely similar over short baselines.
- **Satellite clock drift** — common to all receivers for a given satellite.
- **Orbital (ephemeris) error** — same broadcast for both receivers.

Errors that are *receiver-specific*, such as **receiver clock** and **multipath**, do not cancel reliably with simple DGPS. Therefore the best match is option (B).

(B)

Quick Tip

Remember DGPS removes *common* errors: ionosphere/troposphere, satellite clock, and ephemeris. It cannot fix receiver-unique errors (multipath, receiver clock jitter) without more advanced techniques.

Q.21 The orbital period of GPS satellites is determined by the _____ of their orbits.

- (A) semi-major axis
- (B) eccentricity
- (C) inclination
- (D) semi-major axis, inclination and eccentricity

Correct Answer: (A)

Solution:

From Kepler's third law for two-body motion,

$$T = 2\pi \sqrt{\frac{a^3}{\mu}},$$

where T is the orbital period, a the semi-major axis, and μ Earth's gravitational parameter. T depends only on a (for a given central body), not on eccentricity or inclination. Hence (A).

Quick Tip

Same $a \Rightarrow$ same period: two orbits around Earth with identical semi-major axis (even with different e or i) have identical T .

Q.22 Which vector data analysis tool combines geometries and attributes from different layers?

- (A) Overlay
- (B) Map Manipulation
- (C) Buffer

(D) Cartesian distance measurement

Correct Answer: (A)

Solution:

Overlay (e.g., *Intersect*, *Union*, *Identity*) operates on two or more vector layers, producing output features whose geometries are spatial combinations of inputs and whose attribute tables are merged accordingly. Buffer creates zones around features; Cartesian distance is a measurement; “Map Manipulation” is not a standard vector overlay operator.

Quick Tip

Think: “combine shapes + merge attributes across layers” ⇒ **Overlay**. “Grow/shrink a shape” ⇒ Buffer.

Q.23 A GIS analyst has two raster datasets with the same number of rows and columns. The analyst computes the average of the two input raster layers to generate a new raster layer with the same size as the input raster layers. What type of raster data analysis operation is performed?

- (A) Local
- (B) Neighborhood
- (C) Zonal
- (D) Global

Correct Answer: (A) Local

Reasoning.

Averaging two rasters cell-by-cell (same row/column index) produces an output raster of identical dimensions where each output cell depends *only* on the corresponding input cell values at the same location. This is exactly a **local** (per-cell) raster operation (also called map algebra).

Neighborhood uses a moving window around each cell. **Zonal** aggregates over zones defined by another raster. **Global** uses all cells at once. None of these applies here.

Quick Tip

If the output cell is a function of only the same-location input cell(s), it's a **local** operation. Window-based → neighborhood; zone-based → zonal; whole-image → global.

Q.24 Match the following errors (Column 1) in spatial data digitization with their descriptions (Column 2).

Column 1

(P) Mis-located entities

(Q) Missing labels

(R) Artefacts of digitization

(S) Duplicate labels

(T) Duplicate entities

Column 2

1) Points, lines or boundary segments digitized twice

2) Points, lines or boundary segments digitized in wrong place

3) Undershoots, overshoots, wrongly placed nodes, loops or spikes

4) Undefined polygons

5) Two or more identification labels for same polygon

(A) P-2, Q-4, R-3, S-5, T-1

(B) P-1, Q-2, R-3, S-5, T-4

(C) P-2, Q-1, R-4, S-3, T-5

(D) P-2, Q-4, R-3, S-1, T-5

Correct Answer: (A) P-2, Q-4, R-3, S-5, T-1

P → 2 (Mis-located entities).

“Digitized in the wrong place” directly describes mis-location.

Q → 4 (Missing labels).

Polygons without IDs (labels) are *undefined polygons*.

R → 3 (Artefacts of digitization).

Typical digitizing artefacts include undershoots, overshoots, bad nodes, loops, spikes.

S → 5 (Duplicate labels).

Two or more IDs placed on the same polygon.

T → 1 (Duplicate entities).

The same feature captured twice (points/lines/boundaries).

Quick Tip

Digitizing QA cheat sheet: mis-located = wrong place; artefacts = geometry errors (overshoot/undershoot/spikes); missing labels = undefined polygons; duplicate labels = multiple IDs on one polygon; duplicate entities = same feature traced twice.

Q.25 Which of the following statement(s) is/are TRUE for the least squares adjustment of observations?

- (A) Observations have a Chi-square distribution
- (B) Random errors in the observations are assumed to have a symmetrical distribution
- (C) The positive and negative random observation errors are equally likely
- (D) The adjusted parameters are independent of a priori reference variance

Correct Answer: (B), (C), and (D)

Solution:

- (A) False.** In least squares, the *random errors* (residuals) are assumed zero-mean and (usually) *normally* distributed. The *sum of the weighted squared residuals* (when divided by the reference variance) follows a χ^2 distribution—not the observations themselves.
- (B) True.** The basic assumption is a symmetric error law about zero (normally Gaussian), so the PDF is symmetric.
- (C) True.** With a symmetric zero-mean distribution, $+e$ and $-e$ have equal probability.
- (D) True.** If the weight matrix is $W = \frac{1}{\sigma_0^2} C^{-1}$, the LS estimate $\hat{x} = (A^T W A)^{-1} A^T W \ell$ is unchanged by the scalar factor σ_0^{-2} ; hence adjusted parameters are independent of the (scalar) a priori reference variance. Only *relative* weights matter.

Quick Tip

In LS adjustment: errors $\sim \mathcal{N}(0, \sigma^2)$ (symmetric), the normalized residual sum $\rightarrow \chi^2$, and scaling all weights by the same constant leaves $\hat{x}$ unchanged.

Q.26 Which of the following statement(s) is/are TRUE for the systematic errors?

- (A) These can be corrected by applying a suitable mathematical model
- (B) The least squares adjustment automatically removes unmodelled systematic errors
- (C) These must be removed while or before applying the least squares adjustment
- (D) Removal of gross errors automatically removes systematic errors

Correct Answer: (A) and (C)

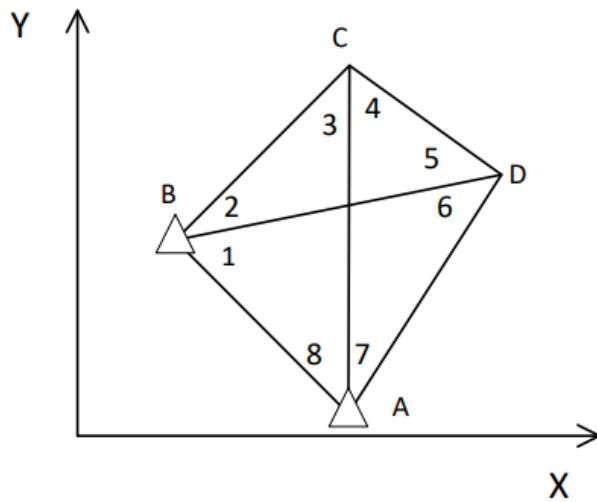
Solution:

- (A) **True.** Systematic errors are repeatable biases and can be modelled (e.g., temperature/scale corrections) and corrected through appropriate functional models or calibration.
- (B) **False.** Least squares minimizes random errors given the model; it *does not* eliminate biases that are not modelled—they propagate into the estimates.
- (C) **True.** Good practice is to detect/model/remove systematic effects before or during adjustment; otherwise they bias the results.
- (D) **False.** Gross (blunder) removal does not imply removal of persistent systematic biases; they are different error classes.

Quick Tip

Random errors $\Rightarrow$ treat with LS; Systematic errors $\Rightarrow$ model/calibrate/remove; Gross errors $\Rightarrow$ detect and discard. LS cannot fix what the model does not represent.

Q.27 In the following figure, A and B are fixed points with known plane rectangular coordinates. C and D are the new points in the control survey whose coordinates are to be determined. For this network, the surveyor has measured all 8 internal angles (1 to 8) and 5 sides BC, CD, DA, AC and BD. The value of redundancy (r) for the given figure will be equal to _____ (In integer).



Correct Answer: 9

Solution:

Redundancy (degrees of freedom) in a network adjustment is

$$r = m - u,$$

where m is the number of independent observations and u is the number of unknown parameters being estimated after fixing the datum.

Here points A, B are fixed (coordinates known). Unknowns are the coordinates of C and D :

$$x_C, y_C, x_D, y_D \Rightarrow u = 4.$$

Observations measured: all 8 internal angles and 5 sides

$$(BC, CD, DA, AC, BD) \Rightarrow m = 8 + 5 = 13.$$

Therefore,

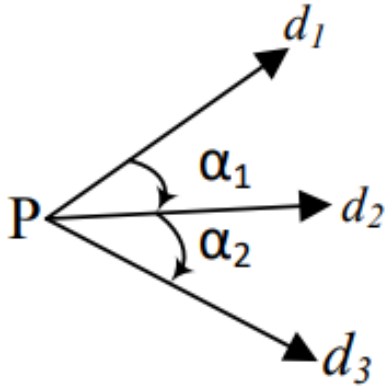
$$r = m - u = 13 - 4 = 9.$$

9

Quick Tip

With control points fixed, the datum is defined; count only the coordinate unknowns of new points. Then $r = m - u$ (angles, distances, directions each count as one observation).

Q.28 As shown in the following figure, let d_1, d_2, d_3 denote three uncorrelated clockwise directions, observed at point P with equal standard errors for each direction, i.e., $\sigma_{d_1} = \sigma_{d_2} = \sigma_{d_3} = \pm\sqrt{2}''$. Let α_1 and α_2 be two included angles formed by these three directions. The covariance matrix (in arcsecond²) for these included angles will be given as:



- (A) $\begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$
- (B) $\begin{bmatrix} 4 & -2 \\ -2 & 4 \end{bmatrix}$
- (C) $\begin{bmatrix} -4 & 2 \\ 2 & -4 \end{bmatrix}$
- (D) $\begin{bmatrix} 4 & 2 \\ -2 & 4 \end{bmatrix}$

Correct Answer: (B)

Solution:

Let the observed directions (random variables) be $\theta_1, \theta_2, \theta_3$ with

$$\text{Var}(\theta_i) = \sigma^2, \quad \sigma^2 = (\sqrt{2})^2 = 2 \text{ (arcsec}^2\text{)}, \quad \text{Cov}(\theta_i, \theta_j) = 0 \ (i \neq j).$$

Define the included angles (clockwise) as

$$\alpha_1 = \theta_1 - \theta_2, \quad \alpha_2 = \theta_2 - \theta_3.$$

Then

$$\text{Var}(\alpha_1) = \text{Var}(\theta_1 - \theta_2) = \sigma^2 + \sigma^2 = 2\sigma^2 = 4,$$

$$\text{Var}(\alpha_2) = \text{Var}(\theta_2 - \theta_3) = \sigma^2 + \sigma^2 = 2\sigma^2 = 4,$$

$$\text{Cov}(\alpha_1, \alpha_2) = \text{Cov}(\theta_1 - \theta_2, \theta_2 - \theta_3) = 0 - 0 - \sigma^2 + 0 = -\sigma^2 = -2.$$

Therefore the covariance matrix is

$$\begin{bmatrix} 4 & -2 \\ -2 & 4 \end{bmatrix}$$

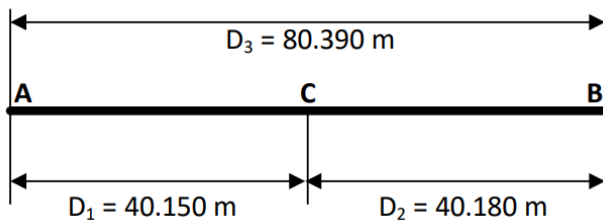
(in arcsecond²).

Quick Tip

For included angles built from independent directions, each angle's variance is the sum of the two direction variances; adjacent included angles share exactly one direction, giving a covariance of $-\sigma^2$.

Q.29 The figure shows three distance observations D_1 , D_2 and D_3 . The table lists values of these observations and the corresponding weights. Assuming uncorrelated observations, the most probable values by the least squares approach for these measurements are (Rounded off to 3 decimal places).

Distance	Measurement (m)	Weight
D_1	40.150	1
D_2	40.180	2
D_3	80.390	1



- (A) $\hat{D}_1 = 40.170$ m, $\hat{D}_2 = 40.190$ m, $\hat{D}_3 = 80.360$ m
 (B) $\hat{D}_1 = 40.174$ m, $\hat{D}_2 = 40.192$ m, $\hat{D}_3 = 80.366$ m
 (C) $\hat{D}_1 = 40.175$ m, $\hat{D}_2 = 40.185$ m, $\hat{D}_3 = 80.360$ m
 (D) $\hat{D}_1 = 40.172$ m, $\hat{D}_2 = 40.195$ m, $\hat{D}_3 = 80.367$ m

Correct Answer: (B)

Solution:

Constraint (from geometry): $D_1 + D_2 - D_3 = 0$. Let residuals be v_i with adjusted $\hat{D}_i = D_i + v_i$ and weights $w = \text{diag}(1, 2, 1)$. The constraint in residuals:

$$v_1 + v_2 - v_3 = -(D_1 + D_2 - D_3) = -(40.150 + 40.180 - 80.390) = +0.060.$$

Minimize $\Phi = v^T W v$ subject to $Av = b$, with $A = [1 \ 1 \ -1]$ and $b = 0.060$. Constrained least squares gives

$$v = W^{-1} A^T (A W^{-1} A^T)^{-1} b.$$

Since $W^{-1} = \text{diag}(1, \frac{1}{2}, 1)$,

$$A W^{-1} A^T = [1 \ 1 \ -1] \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix} = 2.5, \quad (\cdot)^{-1} = 0.4.$$

Thus

$$v = \begin{bmatrix} 1 \\ \frac{1}{2} \\ -1 \end{bmatrix} (0.4 \times 0.060) = \begin{bmatrix} 0.024 \\ 0.012 \\ -0.024 \end{bmatrix} \text{ m.}$$

Therefore (rounded to 3 decimals):

$$\hat{D}_1 = 40.150 + 0.024 = \mathbf{40.174 \text{ m}}, \quad \hat{D}_2 = 40.180 + 0.012 = \mathbf{40.192 \text{ m}}, \quad \hat{D}_3 = 80.390 - 0.024 = \mathbf{80.366 \text{ m}}.$$

Quick Tip

For a single linear condition $Av = b$, the residuals are $v = W^{-1} A^T (A W^{-1} A^T)^{-1} b$. Here b is just the closure error; distribute it according to the inverse weights.

Q.30 Which of the following methods is widely used by the GNSS constellations to distinguish the satellites from each other at the GNSS receiver?

(A) Code Division Multiple Access (CDMA)

- (B) Time Division Multiple Access (TDMA)
- (C) Amplitude Division Multiple Access (ADMA)
- (D) Phase Division Multiple Access (PDMA)

Correct Answer: (A)

Solution:

GNSS satellites (GPS, Galileo, BeiDou and modern GLONASS) transmit on common carrier frequencies but with distinct *spreading codes*. Receivers separate satellites by correlating with each satellite's PRN code—i.e., **CDMA**. (Legacy GLONASS also used FDMA, but CDMA is the widely adopted method across constellations.)

Quick Tip

Think “PRN code per satellite” $\Rightarrow$ CDMA. Different codes, same frequency.

Q.31 For the following data, the slope (m) and intercept (c) of the least squares fitted straight line ($Y = mX + c$) are given as:

<i>Point</i>	X	Y
1	12	14
2	14	16
3	16	17

- (A) Slope = 0.750, Intercept = 5.167
- (B) Slope = 0.850, Intercept = 6.180
- (C) Slope = 0.650, Intercept = 5.558
- (D) Slope = 0.750, Intercept = 5.555

Correct Answer: (A)

Compute sample means.

$$\bar{X} = \frac{12 + 14 + 16}{3} = 14, \quad \bar{Y} = \frac{14 + 16 + 17}{3} = \frac{47}{3} = 15.\bar{6}.$$

Least-squares formulas.

$$m = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2}, \quad c = \bar{Y} - m\bar{X}.$$

Evaluate the sums.

$$\begin{aligned} \sum (X_i - \bar{X})(Y_i - \bar{Y}) &= (-2)(-1.\bar{6}) + 0(0.\bar{3}) + 2(1.\bar{3}) \\ &= 3.\bar{3} + 0 + 2.\bar{6} = 6, \end{aligned}$$

$$\sum (X_i - \bar{X})^2 = 4 + 0 + 4 = 8.$$

Hence $m = \frac{6}{8} = 0.75$, and

$$c = \bar{Y} - m\bar{X} = 15.\bar{6} - 0.75 \times 14 = 15.\bar{6} - 10.5 = 5.16\bar{6} \approx 5.167.$$

$m = 0.750, \quad c = 5.167$

Quick Tip

For a straight-line fit, center the data: compute sums of $(X - \bar{X})(Y - \bar{Y})$ and $(X - \bar{X})^2$. It avoids large-number roundoff and simplifies arithmetic.

Q.32 Which of the following statement(s) is/are CORRECT for sun-synchronous Earth observation satellites?

- (A) They are in near-polar orbit around the Earth
- (B) They cross the equator at different longitudes at nearly the same local solar time
- (C) They maintain nearly the same sun–target–satellite geometry while crossing the equator at different longitudes
- (D) The angle of inclination of their orbit is $< 1^\circ$

Correct Answer: (A), (B), and (C)

(A) **True.** Sun–synchronous orbits are *near-polar* (inclination $\approx 97\text{--}99^\circ$) so the orbital plane precesses with Earth’s revolution to keep constant local solar time.

(B) **True.** By design, the orbital plane precesses $\approx 1^\circ/\text{day}$ to match Earth’s mean motion around the Sun, so each equator crossing occurs at (nearly) the same *local solar time* though at different longitudes on successive passes.

(C) **True.** The constant local time-of-day ensures nearly constant illumination geometry (Sun angle), hence nearly the same sun–target–satellite geometry for observations at different longitudes/days.

(D) **False.** The inclination is not $< 1^\circ$; it is close to 98° (retrograde near-polar).

Correct statements: (A), (B), (C); (D) is false.
--

Quick Tip

Sun–synchronous $\Rightarrow$ near-polar retrograde orbit with nodal precession tuned to keep constant *local solar time* at equator crossings; this preserves illumination geometry across revisits.

Q.33 Which of the following statement(s) is/are CORRECT?

(A) In optical remote sensing, more often we are interested in diffuse reflections

(B) The reflection will be diffuse if the incident wavelength is comparatively much larger than the surface roughness

(C) A surface that reflects microwave in specular manner may reflect the visible in diffuse manner

(D) All wavelengths emitted by the Sun reflect in diffuse manner from the objects on the surface of the Earth

Correct Answer: (A), (C)

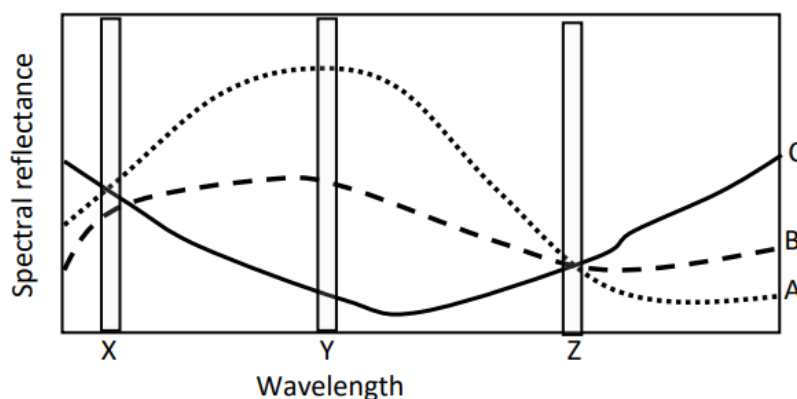
Solution:

- (A) **True.** For most land-surface studies (vegetation, soils), we rely on *diffuse* (Lambertian-like) reflection to infer material properties.
- (B) **False.** If the wavelength λ is *much larger* than the height of surface irregularities ($\lambda \gg h$), the surface appears *optically smooth*, leading to *specular*, not diffuse, reflection. Diffuse scattering occurs when roughness is comparable to or larger than the wavelength.
- (C) **True.** Microwave wavelengths (cm–mm) are far longer than visible (400–700 nm). A surface may be smooth for microwaves (specular) yet rough for visible (diffuse).
- (D) **False.** Earth surfaces can reflect specularly (e.g., sunglint from water, polished metal); not all wavelengths are reflected diffusely.

Quick Tip

“Smooth vs. rough” is *relative* to wavelength: $\lambda \gg h \Rightarrow$ specular; $\lambda \sim h$ or $< h \Rightarrow$ diffuse. Thus the same surface can behave differently across spectral regions.

Q.34 The spectral reflectance curves of three materials (A, B, and C) are shown, along with three wavelength bands X, Y, Z. Which of the following statement(s) is/are **CORRECT**?



- (A) Each of the curve is the spectral signature of the respective material
- (B) A sensor designed for the wavelength band ‘Y’ will best distinguish these materials in the image captured by the sensor
- (C) A sensor designed for the wavelength band ‘Z’ will best distinguish these materials in the image captured by the sensor
- (D) These curves are normally produced using a spectro-radiometer

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

Solution:

(A) True. A plot of reflectance versus wavelength for a material is its *spectral signature*.

(B) True. From the figure, the separation between the reflectances of A, B, C is largest around band Y; hence a band centered at Y provides the best class separability.

(C) False. Around band Z, two of the materials have similar reflectance (curves nearly intersect), yielding poor separability compared to Y.

(D) True. Spectral signatures are typically measured in the field/lab using a *spectro-radiometer* (or field spectrometer).

Quick Tip

For material discrimination, pick bands where class reflectances are maximally separated and intra-class variance is small—often identified directly from spectral signature plots.

Q.35 Which of the following statement(s) is/are TRUE?

(A) Topography is an example of continuous spatial feature

(B) Geo-relational data model stores spatial data and attribute data separately

(C) Object based data model stores spatial data and attribute data together

(D) Land surface temperature is an example of discrete spatial feature

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

Solution:

(A) True. Topography (elevation/terrain) varies continuously over space and is modeled as a continuous field (e.g., raster DEM, TIN surface).

(B) True. In the *geo-relational* model (classic coverages/shape+DBF), geometry is stored in spatial files while attributes are stored separately in a relational table linked via a key.

(C) True. Object/feature-based (geodatabase, O-O) stores geometry and attributes together as an object (with behavior), i.e., an integrated record.

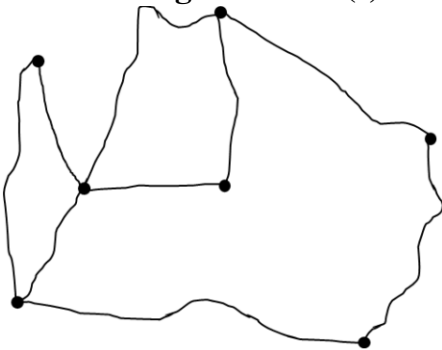
(D) False. Land surface temperature is a spatially *continuous* field (varies everywhere), not a discrete feature.

True: (A), (B), (C) ; False: (D)

Quick Tip

Discrete features are countable objects (roads, parcels, poles). Continuous phenomena (elevation, temperature) exist at every location. Geo-relational = separate geometry/attributes; object-based = integrated.

Q.36 In the network shown below, after converting it to a topological graph, which of the following statement(s) is/are TRUE? (Assume there are no pseudo-nodes)



- (A) The correct number of nodes (or vertices) are 7
- (B) The correct number of edges (or links) are 9
- (C) The total number of regions are 4
- (D) The correct number of edges (or links) are 8

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

Solution:

Count nodes (vertices). Convert to a topological graph by placing a node at every line endpoint and at every intersection (no pseudo-nodes). The figure yields $V = 7$ distinct nodes.

Count edges (links). An edge is the maximal line segment between two consecutive nodes along a path. Tracing each segment between nodes gives $E = 9$ edges.

Check with Euler's formula (planar, single component). For a connected planar graph,

$$F = E - V + 2,$$

where F is the number of faces (regions), including the exterior. With $V = 7$ and $E = 9$,

$$F = 9 - 7 + 2 = 4.$$

Thus the total number of regions is 4. Therefore statements (A), (B), and (C) are true; (D) is false.

$V = 7, \quad E = 9, \quad F = 4$

Quick Tip

When converting a network drawing to a topological graph: (1) mark nodes at all end-points and true intersections; (2) edges are segments between adjacent nodes; (3) verify counts using Euler's formula $F = E - V + 2$ (for a connected planar graph) to avoid miscounts.

Q.37 Which of the following type(s) of tolerances is/are used in editing GIS data?

- (A) Snap tolerance
- (B) Weed tolerance
- (C) Grain tolerance
- (D) Polygon tolerance

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

Solution:

During digitizing/editing, software uses several distance tolerances to control feature creation and cleanup. *Snap tolerance* forces vertices/edges within a set distance to coincide (avoids gaps/overshoots). *Weed tolerance* removes redundant vertices closer than the set threshold (line simplification). *Grain tolerance* (used in some GIS/CAD digitizers) controls the minimum spacing of sampled points while tracing, acting like a densify/sampling

threshold. “*Polygon tolerance*” is not a standard editing tolerance per se (area features are affected by the same snap/weed/grain settings), hence (D) is not chosen.

Quick Tip

Remember: *snap* (merge nearby points), *weed* (delete too-close vertices), *grain* (sampling/spacing while tracing). These stabilize topology and generalization during editing.

Q.38 Choose the CORRECT statement(s) regarding microwave remote sensing.

- (A) Spatial resolution of passive microwave remote sensor is coarser than that of active microwave remote sensor from the same platform
- (B) The intensity of signal returned by an object depends on its geometric as well as dielectric properties
- (C) It is possible to “see through” the dense forest canopy using X-band active microwave remote sensing (i.e. signals can penetrate the dense forest canopy)
- (D) Microwave remote sensing can be used in soil moisture studies

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

Solution:

- (A) *True*. Passive microwave radiometers need large antenna apertures to achieve fine IFOV; from the same platform their spatial resolution is much coarser than active SAR.
- (B) *True*. Backscatter depends on geometry/roughness (surface slope, structure) and dielectric constant (moisture content), among other factors (wavelength, polarization, incidence angle).
- (C) *False*. X-band (~3 cm wavelength) has poor canopy penetration; L-/P-band provide deeper penetration in vegetation.
- (D) *True*. Both passive (brightness temperature) and active (backscatter) microwave methods are widely used for soil moisture retrieval.

Quick Tip

Penetration increases with wavelength: X (short) < C < L < P (long). Soil moisture strongly affects microwave dielectric properties $\Rightarrow$ strong signal sensitivity.

Q.39 Consider the Sun and the Earth as blackbodies at 6000 K and 300 K temperatures, respectively. Which of the following statement(s) is/are *INCORRECT*?

- (A) Sun emits maximum energy at $9.3 \mu\text{m}$
- (B) Sun does not emit energy at microwave
- (C) The wavelengths of the energies emitted by the Sun are a sub-set of the wavelengths emitted by the Earth
- (D) Earth does not emit energy at green wavelength

Correct Answer: (A), (B), and (C)

Use Wien's displacement law: $\lambda_{\text{max}} = \frac{b}{T}$ with $b \approx 2897 \mu\text{m} \cdot \text{K}$.

- For the **Sun** ($T = 6000 \text{ K}$): $\lambda_{\text{max}} \approx \frac{2897}{6000} \approx 0.48 \mu\text{m}$ (visible blue-green). Thus statement (A) claiming $9.3 \mu\text{m}$ is **incorrect**.

- For the **Earth** ($T = 300 \text{ K}$): $\lambda_{\text{max}} \approx \frac{2897}{300} \approx 9.66 \mu\text{m}$ (thermal IR).

(B) Incorrect. A blackbody emits *over all wavelengths* ($\lambda > 0$); the Sun's microwave emission is extremely small but non-zero. Saying it "does not emit" is wrong.

(C) Incorrect. Neither body's emission wavelengths are a subset of the other—both blackbodies emit over a continuous spectrum. The Sun peaks at shortwave (UV-VIS-NIR), Earth at longwave (thermal IR).

(D) Considered correct in remote-sensing context. The Earth's thermal emission at $\sim 0.55 \mu\text{m}$ (green) is negligible (far from its $9\text{--}10 \mu\text{m}$ peak) and is commonly treated as *no emission* in practice, hence (D) is not marked incorrect.

Quick Tip

Wien's law gives the peak: $\lambda_{\text{max}}[\mu\text{m}] \approx \frac{2897}{T[\text{K}]}$. Blackbodies emit at *all* wavelengths; what changes dramatically is the magnitude.

Q.40 Which of the following statement(s) concerning GNSS errors is/are CORRECT?

- (A) Tropospheric delay increases with increasing relative humidity
- (B) Ionospheric error is highly correlated with the position of the Moon
- (C) Multipath error is caused by buildings and man-made features and not by vegetation
- (D) The observed range is called pseudorange because of its erroneous nature

Correct Answer: (A) and (D)

(A) True. Tropospheric delay has a dry (hydrostatic) and a wet component; the wet component grows with water vapour content $\Rightarrow$ higher relative humidity increases delay.

(B) False. Ionospheric delay is driven mainly by solar radiation and geomagnetic activity (diurnal/solar-cycle dependence), not the Moon's position.

(C) False. Multipath arises from reflections/scattering from *any* nearby surface—buildings, metallic structures, ground, and also vegetation (leaves/branches). Vegetation can and does cause multipath (though often weaker).

(D) True. Code-based measured range includes receiver/satellite clock biases and propagation errors, so it is not the true geometric range; hence the term *pseudorange*.

Quick Tip

Remember: ionosphere $\rightarrow$ Sun-driven; troposphere (wet) $\rightarrow$ humidity; multipath $\rightarrow$ any reflecting/scattering environment; pseudorange $\rightarrow$ geometric range + errors.

Q.41 For a push-broom (along-track) sensor the following are known:

Field of view (FoV) = 2 degrees

Instantaneous FoV = 1 milli-radian

Time to scan one full scanline = 2×10^{-2} s

Height above ground = 100 km

The dwell time for a single pixel of this sensor is _____ s. (Rounded off to 2 decimal places)

Correct Answer: 0.02 s

Solution:

For a *push-broom* sensor, an entire cross-track line is imaged *simultaneously* by an array of detectors. Hence a ground pixel remains within the detector's view for the duration of one line acquisition (frame time). Therefore, the pixel dwell time equals the scanline time:

$$t_{\text{dwell}} = t_{\text{scanline}} = 2 \times 10^{-2} \text{ s} = 0.02 \text{ s}.$$

(The given FoV and IFOV are useful to find the number of detectors:

$N \approx \frac{2^\circ}{1 \text{ mrad}} \approx \frac{0.0349}{0.001} \approx 35$, but they *do not* reduce dwell time for push-broom; they would for a whisk-broom scanner, where $t_{\text{dwell}} = t_{\text{scanline}}/N$.)

Quick Tip

Push-broom: pixel dwell time = line (frame) time.

Whisk-broom: pixel dwell time = (scanline time) / (number of instantaneous pixels across-track).

Q.42 The range accuracy with a microsecond accurate clock in the GNSS receiver is about 300 m. If we improve the clock accuracy to 3.33×10^{-x} s, the range accuracy becomes 1 cm. The value of x is _____ (In integer).

Assume the speed of light to be $c = 3 \times 10^8$ m/s and that no other errors are being considered.

Hint: error-free range = speed of light $\times$ time of travel of the signal

Correct Answer: 11

Solution:

For one-way ranging (GNSS code measurement),

$$\Delta R = c \Delta t.$$

Given desired range accuracy $\Delta R = 1 \text{ cm} = 10^{-2} \text{ m}$,

$$\Delta t = \frac{\Delta R}{c} = \frac{10^{-2}}{3 \times 10^8} = 3.33 \dots \times 10^{-11} \text{ s}.$$

Thus $x = 11$. (Sanity check: for $\Delta t = 1 \mu\text{s}$, $\Delta R = c\Delta t = 3 \times 10^8 \times 10^{-6} = 300 \text{ m}$, as stated.)

Quick Tip

GNSS range error $\approx c \Delta t$ (one-way). Improving timing accuracy by 10^n improves range by the same factor.

Q.43 A GPS satellite is flying at a distance of 20,000 km from the observer. The phase of the L1 carrier (1575.42 MHz) in degrees as received by the observer is ____ (Rounded off to 2 decimal places).

Assume that the signal did not experience any refraction, reflection or other errors and the speed of light to be $c = 3 \times 10^8 \text{ m/s}$.

Correct Answer: 0.00°

Solution:

Propagation delay for range $R = 20,000 \text{ km}$:

$$\tau = \frac{R}{c} = \frac{2 \times 10^7}{3 \times 10^8} = \frac{1}{15} \text{ s} = 0.066666 \dots \text{ s}.$$

Number of carrier cycles at $f = 1575.42 \text{ MHz}$:

$$N = f\tau = 1.57542 \times 10^9 \times \frac{1}{15} = 105,028,000.000 \text{ cycles}.$$

Since this is an *integer* number of cycles, the residual phase at reception is

$$\phi = 360^\circ \cdot (N - \lfloor N \rfloor) = 0^\circ.$$

Rounded to two decimals: $\boxed{0.00^\circ}$.

Quick Tip

Received carrier phase (in degrees) $= 360^\circ \times (fR/c \bmod 1)$. If fR/c is an integer, the phase is exactly 0° .

Q.44 For a profile given in the figure in the form of three steps A, B and C, the following information is available:

Height of step A (H_A) with respect to a reference line = 10 m (known and error free)

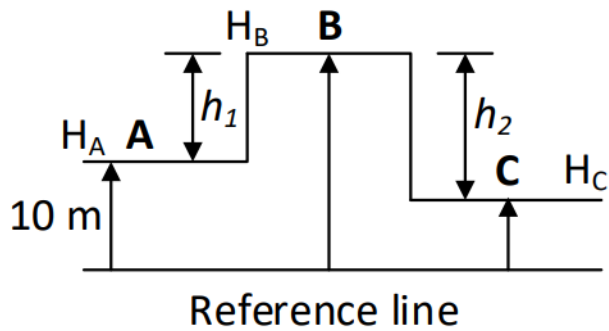
Difference in height between step A and step B (h_1) = 5 m $\pm$ 2 mm

Difference in height between step B and step C (h_2) = 8 m $\pm$ 3 mm

H_B and H_C are the unknown heights of step B and C, respectively. The step B is higher than step C and D.

The coefficient of correlation, $\rho_{h_1 h_2}$, between the height differences = 0.25

The coefficient of correlation between estimated heights of points B and C ($\rho_{H_B H_C}$) will be (Rounded off to 2 decimal places).



Correct Answer: 0.40

Solution:

Let the random (measurement) errors in h_1 and h_2 be zero-mean with standard deviations

$$\sigma_{h_1} = 2 \text{ mm}, \quad \sigma_{h_2} = 3 \text{ mm}, \quad \rho_{h_1 h_2} = 0.25,$$

and $\text{Cov}(h_1, h_2) = \rho_{h_1 h_2} \sigma_{h_1} \sigma_{h_2}$.

Because H_A is known exactly,

$$H_B = H_A + h_1, \quad H_C = H_B - h_2 = H_A + h_1 - h_2.$$

Hence

$$\text{Var}(H_B) = \sigma_{h_1}^2,$$

$$\text{Var}(H_C) = \text{Var}(h_1 - h_2) = \sigma_{h_1}^2 + \sigma_{h_2}^2 - 2 \text{Cov}(h_1, h_2),$$

$$\text{Cov}(H_B, H_C) = \text{Cov}(h_1, h_1 - h_2) = \sigma_{h_1}^2 - \text{Cov}(h_1, h_2).$$

Therefore the correlation coefficient between H_B and H_C is

$$\rho_{H_B H_C} = \frac{\sigma_{h_1}^2 - \rho_{h_1 h_2} \sigma_{h_1} \sigma_{h_2}}{\sqrt{\sigma_{h_1}^2 (\sigma_{h_1}^2 + \sigma_{h_2}^2 - 2\rho_{h_1 h_2} \sigma_{h_1} \sigma_{h_2})}}.$$

Substitute $\sigma_{h_1} = 2$, $\sigma_{h_2} = 3$, $\rho_{h_1 h_2} = 0.25$ (units cancel):

$$\rho_{H_B H_C} = \frac{2^2 - 0.25 \cdot 2 \cdot 3}{\sqrt{2^2 (2^2 + 3^2 - 2 \cdot 0.25 \cdot 2 \cdot 3)}} = \frac{2.5}{\sqrt{40}} \approx 0.3953 \Rightarrow \boxed{0.40}.$$

Quick Tip

When heights are built from correlated differences, express the heights as linear functions of the measurements and propagate: $\text{Var}(aX + bY) = a^2 \sigma_X^2 + b^2 \sigma_Y^2 + 2ab \text{Cov}(X, Y)$ and $\rho_{XY} = \frac{\text{Cov}(X, Y)}{\sigma_X \sigma_Y}$. Adding constants (known H_A) does not affect covariance or correlation.

Q.45 The relative radiance value of a facet of a Triangulated Irregular Network (TIN) can be computed using:

$$R_f = \cos(A_f - A_s) \sin(H_f) \cos(H_s) + \cos(H_f) \sin(H_s)$$

Where, R_f is the relative radiance value of a facet, A_f is the facet's aspect, A_s is the sun's azimuth angle, H_f is the facet's slope and H_s is the sun's altitude. Suppose a facet of a TIN has a slope value of 10° and an aspect value of 297° and sun's azimuth of 315° . For sun's altitude angle of 65° , the relative radiance value of this facet is ----- (Rounded off to 2 decimal places).

Correct Answer: 0.96

Solution:

Insert the angles in the formula (all in degrees):

$$\begin{aligned} R_f &= \cos(297^\circ - 315^\circ) \sin(10^\circ) \cos(65^\circ) + \cos(10^\circ) \sin(65^\circ) \\ &= \cos(-18^\circ) \sin 10^\circ \cos 65^\circ + \cos 10^\circ \sin 65^\circ. \end{aligned}$$

Evaluate the terms:

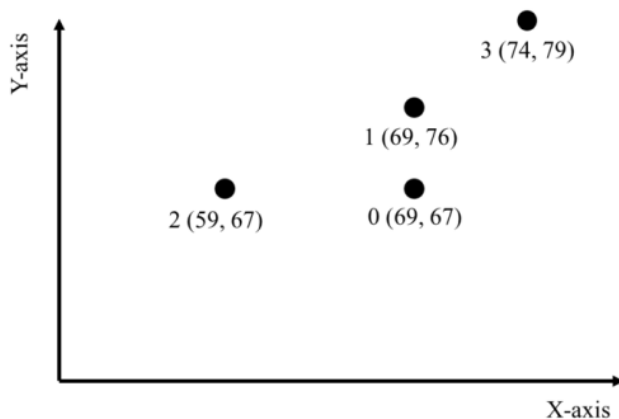
$$\cos(-18^\circ) = 0.95106, \quad \sin 10^\circ = 0.17365, \quad \cos 65^\circ = 0.42262, \quad \sin 65^\circ = 0.90631, \quad \cos 10^\circ = 0.98481.$$

$$\Rightarrow R_f = (0.95106)(0.17365)(0.42262) + (0.98481)(0.90631) = 0.0695 + 0.8928 = 0.9623 \approx \boxed{0.96}.$$

Quick Tip

The first term modulates the slope- and aspect-dependent part with the sun–facet azimuth difference; when the sun is near the facet’s normal (large H_s and small H_f), the second term dominates.

Q.46 The table provides the X- and Y-coordinates of the points, measured in row and column of a raster with cell size of 1 meter, and their known values. Using inverse distance weighted (IDW) interpolation method and Euclidean distance, the interpolated value at Point 0 is _____ (Rounded to 2 decimal places). A constant rate of change in value between points should be assumed.



Point	X	Y	Value
1	69	76	27
2	59	67	10
3	74	79	13
0	69	67	?

Correct Answer: 17.36

Solution:

Step 1: Distances from point 0 (69, 67) (Euclidean).

$$d_1 = \sqrt{(69 - 69)^2 + (76 - 67)^2} = 9,$$

$$d_2 = \sqrt{(59 - 69)^2 + (67 - 67)^2} = 10,$$

$$d_3 = \sqrt{(74 - 69)^2 + (79 - 67)^2} = 13.$$

Step 2: IDW weights (power $p = 1$, i.e. “inverse distance”).

$$w_i = \frac{1}{d_i}, \quad w_1 = \frac{1}{9}, \quad w_2 = \frac{1}{10}, \quad w_3 = \frac{1}{13}.$$

Step 3: IDW estimate.

$$\hat{z}_0 = \frac{\sum w_i z_i}{\sum w_i} = \frac{\frac{27}{9} + \frac{10}{10} + \frac{13}{13}}{\frac{1}{9} + \frac{1}{10} + \frac{1}{13}} = \frac{3 + 1 + 1}{0.11111 + 0.1 + 0.07692} = \frac{5}{0.28803} = 17.359 \approx \boxed{17.36}.$$

Quick Tip

If the power p is not specified for IDW, use $p = 1$ (pure inverse distance). The formula is $\hat{z}(\mathbf{x}) = \frac{\sum_i \frac{z_i}{d_i^p}}{\sum_i \frac{1}{d_i^p}}$. Always compute distances first; normalization by $\sum w_i$ avoids unit issues.

Q.47 The bearing of the line AB from North is $143^\circ 40'$ and angle ABC measured in clockwise direction is $309^\circ 30'$. The bearing of line BC in Quadrantal Bearing System is _____.

- (A) $N3^\circ 10'W$
- (B) $N86^\circ 50'E$
- (C) $N86^\circ 50'W$
- (D) $N3^\circ 10'E$

Correct Answer: (C) $N86^\circ 50'W$

Step 1: Convert the given data to whole-circle bearings (WCB).

WCB of AB is given: $\theta_{AB} = 143^\circ 40'$.

At station B , the back bearing of AB equals

$$\theta_{BA} = \theta_{AB} + 180^\circ = 143^\circ 40' + 180^\circ = 323^\circ 40'.$$

Step 2: Turn the specified clockwise angle at B to get the WCB of BC .

Angle ABC (from BA to BC measured clockwise) is $309^\circ 30'$. Hence

$$\theta_{BC} = \theta_{BA} + 309^\circ 30' = 323^\circ 40' + 309^\circ 30' = 633^\circ 10' \equiv 273^\circ 10' \pmod{360^\circ}.$$

Step 3: Convert WCB to Quadrantal Bearing (QB).

Since $273^\circ 10'$ lies in the **NW** quadrant (270° – 360°),

$$\text{QB} = \text{N}(360^\circ - \theta_{BC})\text{W} = \text{N}(360^\circ - 273^\circ 10')\text{W} = \text{N}86^\circ 50'\text{W}.$$

$$\boxed{\text{N}86^\circ 50'\text{W}}$$

Quick Tip

At a vertex B , first find the *back bearing* of the incoming line. Add the included angle (respecting clockwise/anticlockwise sense) to get the outgoing line's WCB, then convert to quadrantal form by quadrant rules.

Q.48 Which of the following map scale is most suitable for urban planning?

- (A) 1:10,000
- (B) 1:25,000
- (C) 1:50,000
- (D) 1:100,000

Correct Answer: (A) 1:10,000

Urban planning needs detailed depiction of parcels, roads, utilities, building footprints, and land use blocks. Such detail requires a **large-scale** map (small denominator). Typical planning scales are 1:5,000–1:25,000. Among the options, **1:10,000** is the largest scale and therefore most suitable. The others (1:25k, 1:50k, 1:100k) progressively lose detail and are used for regional/topographic overviews rather than urban design.

Quick Tip

Remember: *larger scale* $\Rightarrow$ more detail (denominator smaller). Urban/local planning uses 1:5k–1:25k; regional mapping uses 1:50k or smaller (1:100k, 1:250k, ...).

Q.49 Which of the following statement is NOT true regarding relief displacement in vertical photographs in the context of aerial photogrammetry?

- (A) Relief displacement is the shift in the photographic position of an object caused by the elevation of the object (above or below the datum)
- (B) Relief displacement is always in non-radial direction from the principal point
- (C) Relief displacement can cause straight roads (not passing through the ground principal point) to appear crooked in undulating terrain
- (D) The magnitude of relief displacement is affected by the flying height of the camera (assuming everything else to be same)

Correct Answer: (B)

Solution:

Relief displacement in a (truly) vertical photograph is

$$d = \frac{h}{H} r,$$

where h is the height of the object above (or below, with sign) the datum, H is the flying height above the same datum, and r is the radial distance of the image point from the *principal point*. Hence: - The displacement is **radial** from the principal point (toward it if $h < 0$, away from it if $h > 0$). Therefore statement (B) (“always in non-radial direction”) is **NOT true**.

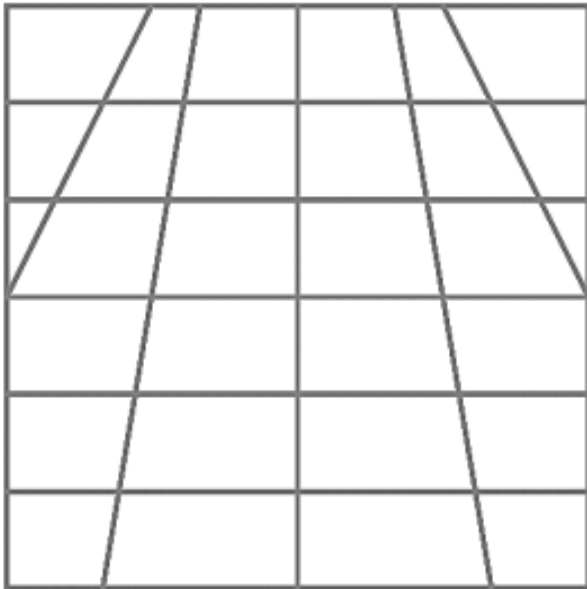
- (A) is the standard definition — **true**.
- (C) is **true** because along an undulating road h varies, so d varies, making a straight road appear crooked if it does not pass through the principal point.

- (D) is **true** since $d \propto 1/H$.

Quick Tip

In a vertical photo: relief displacement is *radial* and obeys $d = (h/H)r$. Larger height h or larger distance r increases d ; larger flying height H decreases d .

Q.50 A square grid is laid on a flat terrain and is photographed from an aerial camera. The flying height and camera parameters are assumed to be constant. The camera and lens are assumed to be perfect (i.e. free from any distortions). The image of the grid obtained from the camera is shown below. Select the **CORRECT** statement from the statements given below.



- (A) Camera is looking directly downwards (towards nadir)
- (B) The given photograph is a vertical photograph
- (C) The given photograph is an oblique photograph
- (D) Scale over the given photograph is constant

Correct Answer: (C)

Solution:

In a **vertical** photograph of a flat terrain (optical axis vertical and image plane parallel to

ground) parallel grid lines remain parallel and, neglecting lens distortion, the scale is uniform. The shown image exhibits *perspective convergence/foreshortening* (grid lines meeting toward a vanishing point), which results from camera *tilt*. Therefore it is an **oblique** photograph. Hence (C) is correct, while (A) and (B) are false. Statement (D) is false because scale is not constant in an oblique photo.

Quick Tip

Parallel lines staying parallel and nearly uniform scale $\Rightarrow$ vertical photo (flat terrain).
Converging lines/foreshortening $\Rightarrow$ oblique photo.

Q.51 Which of the following statement is TRUE for the World Geodetic System 1984 (WGS84)?

- (A) The WGS84 ellipsoid best fits the shape of the earth including its topography
- (B) The WGS84 ellipsoid and the Geodetic Reference System 1980 (GRS80) ellipsoid are one and the same
- (C) The WGS84 ellipsoid is not a geocentric ellipsoid
- (D) The WGS84 ellipsoid can be used to determine the geoid

Correct Answer: (D)

Solution:

(A) False. An ellipsoid is a smooth mathematical surface approximating the Earth; it does *not* include the terrain/topography. WGS84 defines a reference (best-fit, global) ellipsoid, not a topographic surface.

(B) False. WGS84 and GRS80 are very close but not identical (slightly different defining constants/realizations). Saying they are “one and the same” is inaccurate.

(C) False. WGS84 is explicitly geocentric (Earth-Centered, Earth-Fixed frame).

(D) True. The geoid is determined relative to a reference ellipsoid. Using the WGS84 ellipsoid (together with a gravity model) one computes geoid undulation N and thus the geoid. Hence WGS84 *can be used* to determine the geoid surface.

(D)

Quick Tip

Remember the three surfaces: **Topography** (actual terrain), **Geoid** (equipotential, “mean sea level”), and **Ellipsoid** (smooth reference). WGS84 provides the global *geocentric ellipsoid* and frame; geoid models give N above/below that ellipsoid.

Q.52 Which of the following map(s) is/are published by Survey of India?

- (A) Topographical Maps
- (B) Geological Maps
- (C) Soil Maps
- (D) Thematic Maps

Correct Answer: (A)

Solution:

Survey of India (SOI) is the national mapping agency responsible for **topographic/base mapping** (Topo sheets, Open Series/Defense Series maps).

Geological maps are produced by the Geological Survey of India (GSI).

Soil maps are produced primarily by NBSS&LUP (ICAR).

“Thematic maps” is a broad category; in India, national thematic atlases are mainly by NATMO and subject agencies, not core SOI products. Therefore only **Topographical Maps** (A) are the standard SOI publications.

(A)

Quick Tip

Think “who publishes what” in India: **SOI**—topographic base maps; **GSI**—geology; **NBSS&LUP**—soils; **NATMO/line agencies**—thematic layers and atlases.

Q.53 Which of the following triangles are well conditioned and may be suitable for control establishment using triangulation?

Triangle	Interior Angles
I	$90^\circ, 45^\circ, 45^\circ$
II	$130^\circ, 25^\circ, 25^\circ$
III	$110^\circ, 35^\circ, 35^\circ$
IV	$110^\circ, 45^\circ, 25^\circ$

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

Correct Answer: (A) and (C)

Solution:

A well-conditioned triangulation triangle avoids very small or very large angles; in practice, angles are usually kept within about 30° and 120° (best near 60°).

I: $45^\circ, 45^\circ, 90^\circ \in [30^\circ, 120^\circ] \Rightarrow$ good.

II: $25^\circ, 25^\circ, 130^\circ$ (one $< 30^\circ$, one $> 120^\circ$) $\Rightarrow$ poor.

III: $35^\circ, 35^\circ, 110^\circ \in [30^\circ, 120^\circ] \Rightarrow$ good.

IV: $25^\circ (< 30^\circ) \Rightarrow$ poor.

Hence, triangles **I** and **III** are suitable.

Quick Tip

For triangulation, try to keep all angles between 30° and 120° (ideally near 60°) to minimize propagation of angular errors into side lengths.

Q.54 An angle of 90° is to be laid out with a theodolite having a least count of $30''$. The angle was measured by repetition method and was found to be $90^\circ 00' 25''$. The offset

value at a distance of 300 m from the theodolite to set out the *correct* angle is _____ m.
(Rounded off to 3 decimal places).

Correct Answer: 0.036 m

Solution:

Measured angle has an excess of $25''$ over 90° . Required lateral correction at distance $L = 300$ m:

$$\delta = L \tan(\Delta\theta) \approx L \Delta\theta_{\text{rad}}$$

$$\text{with } \Delta\theta = 25'' = \frac{25}{3600}^\circ = \frac{25\pi}{648000} \text{ rad} \approx 1.212 \times 10^{-4}.$$

$$\Rightarrow \delta \approx 300 \times 1.212 \times 10^{-4} = 0.03636 \text{ m} \approx \boxed{0.036 \text{ m}}.$$

(The least count is immaterial to the offset computation.)

Quick Tip

Small-angle field corrections: $\delta \approx L \Delta\theta_{\text{rad}}$. Convert arc-seconds to radians via $1'' = \pi/648000$ rad.

Q.55 The following vertical circle readings were taken by a theodolite set up at station A to observe targets located at P and Q. Find the vertical angle PAQ .

Instrument at	Sighted to	Observation - 1		Observation - 2	
		Vernier C	Vernier D	Vernier C	Vernier D
A	P	$3^\circ 10' 10''$	$10' 20''$	$3^\circ 10' 30''$	$10' 50''$
A	Q	$-2^\circ 40' 40''$	$41' 00''$	$-2^\circ 41' 20''$	$41' 10''$

- (A) $1^\circ 51' 25''$
- (B) $1^\circ 51' 30''$
- (C) $5^\circ 51' 25''$
- (D) $5^\circ 51' 30''$

Correct Answer: (D) $5^{\circ}51'30''$

Step 1: Mean vertical angle to each target (two-face observation).

Using the Vernier-C readings (face left and face right) to eliminate index error:

$$\text{For } P: v_P = \frac{3^{\circ}10'10'' + 3^{\circ}10'30''}{2} = 3^{\circ}10'20''.$$

$$\text{For } Q: v_Q = \frac{(-2^{\circ}40'40'') + (-2^{\circ}41'20'')}{2} = -2^{\circ}41'00''.$$

Step 2: Required angle PAQ .

$$\angle PAQ = v_P - v_Q = 3^{\circ}10'20'' - (-2^{\circ}41'00'') = 5^{\circ}51'20'' \approx 5^{\circ}51'30''.$$

(Nearest choice.)

$$5^{\circ}51'30''$$

Quick Tip

With a properly adjusted theodolite, take face-left and face-right (two-face) readings and *average* them to remove index error; then difference the means to get the included vertical angle.

Q.56 An aerial photograph is to be taken from a flying height of 2 km above a flat ground with a camera having a focal length of 200 mm. The image format used is 23 cm $\times$ 23 cm. The ground area covered by a single photograph is _____ km^2 .

- (A) 5.29
- (B) 1.48
- (C) 0.95
- (D) 2.22

Correct Answer: (A) 5.29

Step 1: Photo scale.

Flying height above ground $H = 2 \text{ km} = 2,000 \text{ m} = 2,000,000 \text{ mm}$. Focal length $f = 200 \text{ mm}$.

$$\text{Scale } S = \frac{f}{H} = \frac{200}{2,000,000} = 1:10,000.$$

Step 2: Ground coverage of one side.

Photo side = 23 cm = 0.23 m. Ground side = $0.23 \times 10,000 = 2,300 \text{ m} = 2.3 \text{ km}$.

Step 3: Area.

$$A = (2.3 \text{ km})^2 = 5.29 \text{ km}^2.$$

5.29 km^2

Quick Tip

For vertical photos over flat terrain: $\text{scale} = f/H$. Multiply the photo side by the scale denominator to get the ground side; square it for area (for square formats).

Q.57 The scaled and rotated versions of vectors $[1, 2]$ and $[-3, 4]$ are

- (A) $[-1, 3], [-7, 1]$
- (B) $[5, 7], [-7, 3]$
- (C) $[2, -3], [-7, 1]$
- (D) $[2, -3], [-7, 3]$

Correct Answer: (A) $[-1, 3], [-7, 1]$

Solution:

A “scaled + rotated” transform has the form $T = sR$, where R is a 2×2 rotation matrix and $s > 0$ is a scalar. Such a transform preserves the angle between vectors and scales *all* lengths by the same factor s ; hence for input vectors $\mathbf{u} = [1, 2]$ and $\mathbf{v} = [-3, 4]$:

$$\frac{\|\mathbf{v}'\|}{\|\mathbf{u}'\|} = \frac{s\|\mathbf{v}\|}{s\|\mathbf{u}\|} = \frac{\|\mathbf{v}\|}{\|\mathbf{u}\|} = \frac{5}{\sqrt{5}} = \sqrt{5}.$$

Check option (A): $\|[-1, 3]\| = \sqrt{10}$ and $\|[-7, 1]\| = \sqrt{50}$, so the ratio is $\sqrt{50}/\sqrt{10} = \sqrt{5}$ — matches. Also the dot product must scale by s^2 : $\mathbf{u} \cdot \mathbf{v} = 5$. With

$s = \frac{\|[-1, 3]\|}{\|\mathbf{u}\|} = \frac{\sqrt{10}}{\sqrt{5}} = \sqrt{2}$, we get $s^2(\mathbf{u} \cdot \mathbf{v}) = 2 \cdot 5 = 10$, and indeed $[-1, 3] \cdot [-7, 1] = 7 + 3 = 10$. Options (B)–(D) fail the constant-length-ratio test, so (A) is the only valid pair.

Quick Tip

For “rotation + uniform scaling”: (i) angle between vectors is preserved; (ii) the ratio of lengths is unchanged; (iii) dot products scale by the same s^2 factor.

Q.58 Find the best match between Column 1 and Column 2

Column 1

Column 2

P: Trilateration

1. Measurements of lengths and directions of all sides

Q: Triangulation

2. Measurements of all the sides of a triangle

R: Traversing

3. Measurements of all the interior angles of a triangle

S: Resection

4. Determination of occupied position with the help of known stations

(A) P–4; Q–2; R–3; S–1

(B) P–1; Q–3; R–2; S–4

(C) P–4; Q–3; R–2; S–1

(D) P–2; Q–3; R–1; S–4

Correct Answer: (D) P–2; Q–3; R–1; S–4

Solution:

Trilateration determines positions from *measured lengths* $\Rightarrow$ (2).

Triangulation fixes positions by *measuring angles* in triangles $\Rightarrow$ (3).

Traversing requires *both lengths and directions* of traverse legs $\Rightarrow$ (1).

Resection finds the occupied station using observations to *known stations* $\Rightarrow$ (4).

Quick Tip

Remember: Tri/ateration $\rightarrow$ lengths; Triangulation $\rightarrow$ angles; Traversing $\rightarrow$ lengths & directions; Resection $\rightarrow$ your position from known points.

Q.59 Which of the following statement(s) is/are CORRECT?

- (A) WGS84 ellipsoid is an oblate ellipsoid
- (B) GPS positioning gives the orthometric height of a place
- (C) Height of a point above the geoid is its ellipsoidal height
- (D) Shape of geoid changes with time

Correct Answer: (A), (D)

Solution:

(A) True. WGS84 defines a *geocentric, oblate* reference ellipsoid (flattened at the poles: $a > b$).

(B) False. Stand-alone GPS provides *ellipsoidal height* h above the WGS84 ellipsoid. Orthometric height H (height above the geoid/mean sea level) requires $H = h - N$ using a geoid undulation N .

(C) False. “Height above the geoid” is the *orthometric* height, not ellipsoidal. Ellipsoidal height is above the reference ellipsoid.

(D) True. The geoid is an equipotential surface of Earth’s gravity field; mass redistribution (hydrology, ice, oceans) makes the gravity field—and thus the geoid—*time-variable* at the centimeter scale.

Correct: (A), (D)

Quick Tip

Keep the trio straight: **Ellipsoid** (smooth reference) $\Rightarrow$ ellipsoidal height h ; **Geoid** (MSL) $\Rightarrow$ orthometric height H ; relation: $h = H + N$ where N is geoid undulation.

Q.60 For a constant flying height, the average scale of an aerial photograph depends on which of the following parameter(s)?

- (A) Focal length of the camera
- (B) Size of the photograph
- (C) Size of the objects in the area
- (D) Topography of the ground

Correct Answer: (A), (D)

Solution:

The photographic scale at a ground point is $S = \frac{f}{H - h_g}$, where f is camera focal length, H is flying height above datum, and h_g is ground elevation at that point.

With *constant* H , the *average* scale over the area depends on:

- f — longer focal length $\Rightarrow$ larger scale (less reduction).
- Ground elevations h_g — relief/topography causes local scale changes; the average depends on terrain heights.

It does *not* depend on the photo's physical size or on "size of objects." Hence (A) and (D) only.

Correct: (A), (D)

Quick Tip

For vertical aerials: local scale $S \approx f/(H - h_g)$. Fix H and think "change f or change h_g ." Photo size or object sizes do not enter the scale formula.

Q.61 Which of the following statement(s) is/are CORRECT?

- (A) Mean sea level is defined as the long-term mean of the tide gauge measurements at a given location

- (B) Mean sea level is the same as the mean tide level
- (C) Mean sea level is defined as the monthly mean of the tide gauge measurements
- (D) Mean sea level is an approximation of geoid

Correct Answer: (A), (D)

Solution:

- (A) *True.* Mean Sea Level (MSL) is the long-term average of sea level observed at a tide gauge (typically many years; e.g., 19-year tidal epoch) at a fixed location.
- (B) *False.* “Mean tide level” is the average of the mean high water and mean low water; it is not the same as the long-term mean sea level.
- (C) *False.* A monthly mean is too short to define MSL; long-term averaging is required to remove periodic tidal and seasonal effects.
- (D) *True.* MSL at gauges is often used as a practical realization/approximation of the geoid (zero-elevation surface) for vertical datums.

Quick Tip

Remember: **MSL** = long-term tide-gauge average (years), used to realize vertical datums; **mean tide level** = average of mean high mean low water (a tidal statistic).

Q.62 Following is the page of a field book used for levelling. Few readings marked with ‘-’ are illegible. The Reduced Level (RL) of the Temporary Bench Mark (TBM) is _____ m (Rounded off to 2 decimal places). All the readings are in m.

Back Sight	Fore Sight	Height of Instrument	RL	Remarks
—	—	101.50	100.00	Bench Mark (BM)
3.50	2.00	103.00	—	
1.50	2.50	—	100.50	
—	0.50	—	?	TBM

Correct Answer: 101.50 m

Solution (Height of Instrument method, reconstructing the illegible entries):

Setup 1: At BM, $RL(BM) = 100.00$ m and $HI_1 = 101.50$ m. Back sight on BM is $BS_1 = HI_1 - RL(BM) = 101.50 - 100.00 = 1.50$ m (illegible in the book). Foresight to Turn Point 1 (TP1) is shown in the next row as $FS_1 = 2.00$ m, so

$$RL(TP1) = HI_1 - FS_1 = 101.50 - 2.00 = 99.50 \text{ m.}$$

Setup 2: With $BS_2 = 3.50$ m on TP1 and $HI_2 = 103.00$ m (given), the same $RL(TP1)$ checks:

$$RL(TP1) = HI_2 - BS_2 = 103.00 - 3.50 = 99.50 \text{ m.}$$

Foresight to Turn Point 2 (TP2) is $FS_2 = 2.50$ m (row 3), hence

$$RL(TP2) = HI_2 - FS_2 = 103.00 - 2.50 = 100.50 \text{ m (matches table).}$$

Setup 3: $BS_3 = 1.50$ m on TP2, so

$$HI_3 = RL(TP2) + BS_3 = 100.50 + 1.50 = 102.00 \text{ m.}$$

Final foresight to TBM is $FS_3 = 0.50$ m, therefore

$$RL(TBM) = HI_3 - FS_3 = 102.00 - 0.50 = 101.50 \text{ m.}$$

Quick Tip

When entries are missing, use turning-point equality: the RL obtained from the previous setup's foresight must equal the RL obtained from the next setup's backsight. Then continue with $HI = RL + BS$ and $RL = HI - FS$.

Q.63 The zone number of Universal Transverse Mercator (UTM) projection having a longitude of $67^\circ 20' 30''$ E is _____ (In integer).

Correct Answer: 42

Step 1: UTM zone formula.

UTM zones are 6° wide in longitude, numbered from 1 at 180° W eastwards. For a longitude λ (east positive), the zone number is

$$Z = \left\lfloor \frac{\lambda + 180^\circ}{6^\circ} \right\rfloor + 1.$$

Step 2: Compute for $\lambda = 67^\circ 20' 30'' = 67.3417^\circ$.

$$\frac{\lambda + 180^\circ}{6^\circ} = \frac{247.3417^\circ}{6^\circ} = 41.2236 \Rightarrow Z = \lfloor 41.2236 \rfloor + 1 = 41 + 1 = 42.$$

42

Quick Tip

UTM zones: $Z = \lfloor (\lambda + 180)/6 \rfloor + 1$ with λ in degrees (E positive, W negative). Each zone spans 6° of longitude.

Q.64 A pair of overlapping vertical photographs were taken from a flying height of 1230 m above sea level with a camera having a focal length of 152.4 mm. The distance between the consecutive exposure stations is 350 m. The parallax bar reading of a point A on the photograph is observed as 10.96 mm. The parallax bar constant for this setup is given as 80.71 mm. The elevation of point A above sea level is _____ m (Rounded off to 2 decimal places).

Correct Answer: ≈ 648.00 m

Key relation (vertical photographs).

Absolute stereoscopic parallax of a point:

$$p = \frac{B f}{H - h}, \quad \Rightarrow \quad h = H - \frac{B f}{p},$$

where B is the air base (distance between exposure stations), f the focal length, H the flying height above datum (MSL here), and h the elevation of the ground point.

Step 1: Determine the absolute parallax p .

With a parallax wedge/bar, the *absolute* parallax equals the bar constant plus the observed reading:

$$p = C + r = 80.71 \text{ mm} + 10.96 \text{ mm} = 91.67 \text{ mm}.$$

Step 2: Compute the elevation.

Use consistent units: let B and H, h be in metres; f and p in millimetres.

$$h = 1230 - \frac{350 \times 152.4}{91.67} = 1230 - 582.0 \approx 648.0 \text{ m.}$$

$$h \approx 648.00 \text{ m}$$

Quick Tip

For absolute height from a stereo pair: (i) get absolute parallax $p = C + r$ (bar constant + reading), (ii) use $h = H - \frac{Bf}{p}$ with B, H in the same length unit and f, p in the same (typically mm).

Q.65 A perfectly adjusted tacheometer is set at a point A having Reduced Level (RL) of 80.50 m and the following readings are taken to the staff held at point B having RL of 80.10 m.

Instrument at	Staff at	Vertical Circle reading	Stadia readings (m)	
			Upper	Lower
A	B	$0^\circ 0' 0''$	2.20	1.80

The height of the instrument from the ground above point A is _____ m (Rounded off to 2 decimal places).

Correct Answer: 1.60 m

Solution:

For a *perfectly adjusted* tacheometer, the multiplying constant $K = 100$ and the additive constant $C = 0$. The vertical circle is 0° , hence the line of sight is horizontal.

Stadia intercept: $s = 2.20 - 1.80 = 0.40 \text{ m}$.

Distance $AB = Ks + C = 100(0.40) + 0 = 40 \text{ m}$ (not directly needed below).

With a horizontal line of sight, the *central hair* reading equals the difference between the height of instrument (HI) and the ground at B: $r_m = \frac{2.20 + 1.80}{2} = 2.00 \text{ m} \Rightarrow \text{HI} = \text{RL}(B) + r_m = 80.10 + 2.00 = 82.10 \text{ m}$.

Therefore, height of instrument at A above the ground at A is

$$HI - RL(A) = 82.10 - 80.50 = 1.60 \text{ m.}$$

Quick Tip

With $VC = 0^\circ$, the line of sight is horizontal, so the middle-hair reading equals the height difference between HI and staff station ground. For a perfectly adjusted tacheometer, use $K = 100$, $C = 0$.

Q.66 The purpose of thresholding in supervised classification is

- (A) to reject homogeneous classes
- (B) to correct the geometry of the image
- (C) to identify image speckle
- (D) to identify and reject pixels not belonging to pre-defined training classes

Correct Answer: (D)

Solution:

After training a supervised classifier, each pixel gets a class label along with a confidence/distance measure (e.g., maximum likelihood probability, minimum-distance value). *Thresholding* sets a limit on this measure so that pixels with low confidence (i.e., not sufficiently similar to any training class) are **rejected**/left unclassified. It is not used to fix geometry (B), detect speckle (C), or reject “homogeneous classes” (A).

Quick Tip

Think “reject option”: apply a decision threshold on class likelihood/distance so that only well-supported pixels are labeled; others are marked as *unknown*.

Q.67 The pixel values for a 3 band and 8-bit image are (127, 127, 127). On an RGB colour display, this pixel will appear -----.

- (A) green
- (B) black
- (C) gray
- (D) white

Correct Answer: (C) gray

Solution:

In an 8-bit RGB image, each channel (R,G,B) ranges from 0 to 255. Equal intensities in all three channels produce a neutral colour (no hue):

- (0,0,0) → black,
- (255,255,255) → white,
- any equal mid-level like (127,127,127) → mid-**gray**.

gray

Quick Tip

RGB with $R = G = B$ gives a gray level; the value sets brightness: low → dark, high → bright.

Q.68 The value at the center pixel of the image at (1) obtained after applying the filter given at (2) is

67	67	72
70	68	71
72	71	72

Image: (1)

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Filter: (2)

- (A) 70
- (B) 68
- (C) 69
- (D) 71

Correct Answer: (A) 70

Solution:

The filter is a 3×3 mean (box) filter with all coefficients $1/9$. The new center value is the average of the 3×3 neighborhood:

Image block:

67	67	72
70	68	71
72	71	72

Sum = $67 + 67 + 72 + 70 + 68 + 71 + 72 + 71 + 72 = 630$.

Mean = $630/9 = 70$. Hence the center becomes 70.

Quick Tip

A 3×3 mean filter replaces each pixel by the average of its 9 neighbors; it smooths noise but blurs edges.

Q.69 To store a 3 band, 4-bit, 512×512 size image (without header) the number of storage bits required are

- (A) 31,45,728
- (B) 6,144
- (C) 10,48,576
- (D) 1,25,82,912

Correct Answer: (A)

Solution:

Pixels = $512 \times 512 = 262,144$. Each pixel has $3 \text{ bands} \times 4 \text{ bits/band} = 12 \text{ bits}$. Total bits = $262,144 \times 12 = 3,145,728 \text{ bits} = \boxed{31,45,728}$ (as written with Indian commas). (= $3,145,728/8 = 393,216 \text{ bytes} \approx 384 \text{ KB}$.)

Quick Tip

Storage (no header, no compression) = (rows $\times$ cols) $\times$ (bands) $\times$ (bits per band).

Q.70 A child travelling in a bus is staring at the wheels of a car. To the child's amusement the car wheels appear to spin backwards, but the car moves forward. This perception is because of the nature of our human visual sensory system, and is attributed to _____.

- (A) aliasing
- (B) convolution
- (C) filtering
- (D) modulation

Correct Answer: (A)

Solution:

The “wagon-wheel effect” occurs when the temporal sampling (visual frames perceived by the eye/brain, or by a camera) is below twice the wheel's spoke-passing frequency (violating the Nyquist rate). Under-sampling causes *aliasing*, which can make the rotation appear slower, stationary, or even reversed.

Quick Tip

If the sampling rate $f_s < 2f$ (signal frequency), perceived frequency folds back as $|f - kf_s|$ —the essence of temporal aliasing.

Q.71 Which one of the following is NOT a linear operation?

- (A) Convolution
- (B) Moving average
- (C) Filtering with a median filter
- (D) Similarity transformation

Correct Answer: (C)

Convolution is a linear operator (it satisfies additivity and homogeneity).

The moving-average filter is a special case of linear convolution with a box kernel.

A similarity transformation (uniform scale + rotation + optional translation) is linear in the intensity domain and affine in geometry; it preserves linearity of combinations of signals.

The **median filter** selects the median of samples in a window, which does *not* satisfy additivity or homogeneity (e.g., $\text{median}(x + y) \neq \text{median}(x) + \text{median}(y)$). Hence it is **nonlinear**.

Quick Tip

Any filter that computes a weighted sum is linear. Order-statistic filters (median, min, max) are nonlinear.

Q.72 The minimum number of 2-dimensional ground control points (GCPs) required for second-order polynomial mapping for image georeferencing is:

- (A) 4
- (B) 5
- (C) 6
- (D) 7

Correct Answer: (C) 6

A 2D second-order polynomial transformation is

$$X' = a_0 + a_1X + a_2Y + a_3X^2 + a_4XY + a_5Y^2, \quad Y' = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2.$$

There are 6 coefficients for X' and 6 for $Y' \Rightarrow$ **12 unknowns**.

Each GCP supplies two equations (one for X' , one for Y'), so the minimum number of GCPs is

$$\frac{12 \text{ unknowns}}{2 \text{ equations/GCP}} = 6.$$

Quick Tip

For 2D polynomial georeferencing, a k th-order model has $\frac{(k+1)(k+2)}{2}$ terms per coordinate. Multiply by 2 (for X' and Y') to get the number of unknowns, then divide by 2 to get the minimum GCPs.

Q.73 Consider an across-track multispectral scanner with ground pixel size of $56 \text{ m} \times 79 \text{ m}$ in the along-track and across-track directions. Which of the following statement is TRUE?

- (A) Aspect ratio distortion of the image will be greater than 1
- (B) Aspect ratio distortion of the image will be less than 1
- (C) There will be no geometric distortion in the image
- (D) Aspect ratio distortion is a type of radiometric distortion

Correct Answer: (A)

Solution:

The **aspect ratio** of the ground pixel is defined as

$$\text{AR} = \frac{\text{across-track GSD}}{\text{along-track GSD}} = \frac{79}{56} = 1.41 > 1.$$

Since the ground sampling distances (GSDs) are unequal, the pixel is rectangular and the image exhibits an *aspect ratio distortion* greater than 1. (B) is false because $\text{AR} > 1$; (C) is false since unequal GSDs imply geometric distortion; (D) is false—aspect ratio is a *geometric* (not radiometric) effect.

Quick Tip

Aspect ratio (AR) = across-/along-track GSD. $\text{AR} = 1 \Rightarrow$ square pixel (no aspect ratio distortion); $\text{AR} \neq 1 \Rightarrow$ rectangular pixel (geometric distortion).

Q.74 The contingency table below is obtained after an image classification. The overall classification accuracy (O) is given as

		Classes on Reference map				
		Class 1	Class 2	Class 3	Class 4	Class 5
Classes on classified map	Class 1	10	1	1	2	3
	Class 2	1	25	1	2	2
	Class 3	0	2	35	1	2
	Class 4	1	1	0	15	1
	Class 5	2	2	1	1	20

- (A) $O = 0.795$
 (B) $O = 0.850$
 (C) $O = 0.725$
 (D) $O = 0.754$

Correct Answer: (A)

Solution:

Overall accuracy O is the ratio of correctly classified samples to the total number of samples:

$$O = \frac{\text{trace of confusion matrix}}{\text{sum of all entries}} = \frac{10 + 25 + 35 + 15 + 20}{132} = \frac{105}{132} = 0.79545 \approx 0.795.$$

Quick Tip

From a confusion matrix: Overall accuracy = (sum of diagonal) / (grand total). Producer's and user's accuracies use column- and row-wise normalizations, respectively.

Q.75 Divergence analysis in classification is used:

- (A) to decorrelate a given set of bands used in classification
- (B) to logically smooth the classified image
- (C) to segregate mixed and homogeneous pixels
- (D) to evaluate statistical separability amongst class pairs

Correct Answer: (D)

Solution:

In supervised classification, we assess how well two classes are separated in feature space.

Divergence (and its variants such as *Transformed Divergence* or *Bhattacharyya distance*) quantify the *statistical separability* between class pairs using class mean vectors and covariance matrices. A larger divergence indicates better separability and lower expected classification error.

- (A) PCA/Decorrelation stretch is for band decorrelation, not divergence.
- (B) Smoothing is a post-classification spatial filtering step.
- (C) Mixed vs homogeneous pixels are not determined by divergence directly.

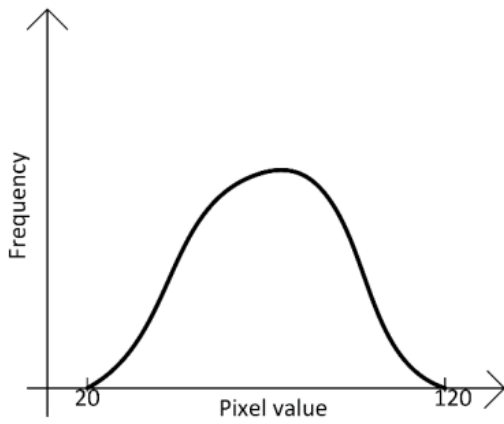
Thus, divergence analysis is for **evaluating separability among class pairs**.

(D)

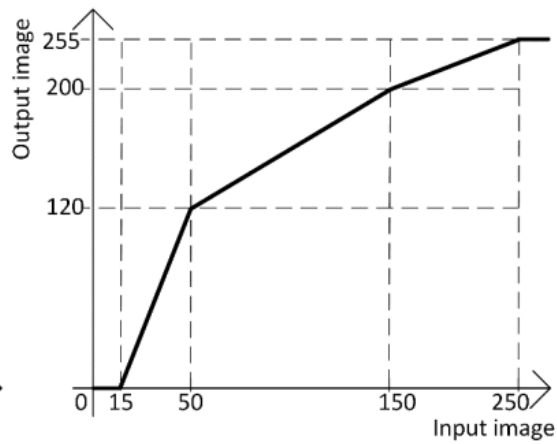
Quick Tip

Use separability measures (Divergence, Transformed Divergence, Jeffries–Matusita, Bhattacharyya) to compare training sets before running a classifier; choose bands/classes with high separability.

Q.76 Consider the histogram of an 8-bit image given below at (1). A piece-wise linear contrast stretch given at (2) is applied on the said image. The minimum and maximum pixel values of the image obtained after applying the given contrast stretch are ----- (minimum value) and ----- (maximum value), respectively.



Histogram of the given image (1)



Piece-wise linear contrast stretch (2)

- (A) 17, 176
- (B) 17, 120
- (C) 20, 176
- (D) 20, 120

Correct Answer: (A) 17, 176

Solution:

From the histogram (1), the input gray levels present in the image span approximately 20 to 120.

The piecewise linear stretch (2) shows breakpoints at $x = 15, 50, 150, 250$ with mapping

$$(15, 0) \rightarrow (50, 120) \rightarrow (150, 200) \rightarrow (250, 255).$$

Hence, - For $15 \leq x \leq 50$: slope $m_1 = \frac{120 - 0}{50 - 15} = \frac{120}{35} = 3.4286$. Input minimum $x_{\min} = 20$ maps to

$$y_{\min} = 0 + m_1(20 - 15) \approx 3.4286 \times 5 \approx \boxed{17}.$$

- For $50 \leq x \leq 150$: slope $m_2 = \frac{200 - 120}{150 - 50} = \frac{80}{100} = 0.8$. Input maximum $x_{\max} = 120$ (falls in this segment) maps to

$$y_{\max} = 120 + m_2(120 - 50) = 120 + 0.8 \times 70 = \boxed{176}.$$

Therefore the stretched image will have minimum 17 and maximum 176.

Quick Tip

For piecewise linear contrast stretches: read the breakpoints (x_i, y_i) , compute the slope for the segment that contains your input gray level, and apply $y = y_i + m(x - x_i)$. Use the image's actual min/max to find the output range.

Q.77 The variance–covariance matrix for a 3-band image is given below (bands in the order 1, 2, 3). Which of the statement(s) is/are CORRECT?

$$\Sigma = \begin{bmatrix} 9 & 2 & 4 \\ 2 & 9 & -3 \\ 4 & -3 & 9 \end{bmatrix}$$

- (A) The standard deviation of all bands is the same
- (B) The bands 1 and 2 are positively correlated
- (C) The bands 2 and 3 are positively correlated
- (D) A line fitted to the scattergram between band 1 and band 3 will have a positive slope

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

Solution:

- From the diagonal of Σ , $\text{var}(1) = \text{var}(2) = \text{var}(3) = 9 \Rightarrow \sigma_1 = \sigma_2 = \sigma_3 = \sqrt{9} = 3$. Hence (A) is **True**.
- Covariance $\text{cov}(1, 2) = 2 > 0 \Rightarrow$ correlation between bands 1 and 2 is positive $\Rightarrow$ (B) **True**.
- $\text{cov}(2, 3) = -3 < 0 \Rightarrow$ bands 2 and 3 are *negatively* correlated $\Rightarrow$ (C) **False**.
- The (least-squares) regression slope of band 3 on band 1 is

$$\beta_{3|1} = \frac{\text{cov}(1, 3)}{\text{var}(1)} = \frac{4}{9} > 0,$$

and the slope of band 1 on band 3 is $\beta_{1|3} = 4/9 > 0$ as well. Hence the fitted line in the 1–3 scattergram has positive slope $\Rightarrow$ (D) **True**.

Quick Tip

Sign of covariance $\Rightarrow$ sign of correlation *and* of the regression slope ($\beta = \text{cov}/\text{var}$).
Diagonal entries of the covariance matrix are the variances.

Q.78 Which of the following statement(s) is/are TRUE regarding color theory:

- (A) Subtractive color theory is used for color printing
- (B) Additive color theory is used to display images on a color television screen
- (C) White light projected on a translucent filter made of yellow dye would subtract the blue light
- (D) White light projected on a translucent filter made of cyan dye would subtract the green light

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

Solution:

- (A) *True*. Color printers use the **subtractive** model (CMY/CMYK): inks subtract components of white light.
- (B) *True*. Displays/TVs use the **additive** model (RGB): light from primaries adds to form colors.
- (C) *True*. A yellow filter transmits red + green and absorbs (subtracts) **blue**.
- (D) *False*. A cyan filter transmits green + blue and absorbs **red**, not green.

Quick Tip

Additive (RGB) $\rightarrow$ emit light (screens). Subtractive (CMY[K]) $\rightarrow$ absorb light (pigments/printing). Yellow removes blue; cyan removes red; magenta removes green.

Q.79 Pixel (x, y) indicates a pixel at location x, y in the image coordinate system. Which of the following statement(s) is/are CORRECT?

- (A) Pixels $(x + 1, y)$ and $(x, y + 1)$ are the adjacent horizontal and vertical neighbors of pixel

(x, y) , respectively

(B) The digital number at pixel (x, y) will always be the average of the digital numbers of pixels $(x - 1, y)$ and $(x + 1, y)$

(C) Pixel $(x - 1, y - 1)$ is *not* an adjacent neighbor of pixel $(x + 1, y + 1)$

(D) Pixel (x, y) has only four diagonal adjacent neighbors

Correct Answer: (A), (C), and (D)

(A) **True.** By definition of 4-/8-neighborhoods on the image grid, $(x \pm 1, y)$ are the horizontal neighbors and $(x, y \pm 1)$ are the vertical neighbors of (x, y) .

(B) **False.** A pixel value (DN) equals the average of left and right neighbors only if a *specific* 1D smoothing/averaging filter has been applied. In general images, $I(x, y)$ is independent and need not equal $\frac{1}{2}\{I(x - 1, y) + I(x + 1, y)\}$.

(C) **True.** $(x - 1, y - 1)$ and $(x + 1, y + 1)$ are separated by $\Delta x = \Delta y = 2$; they are two pixels apart diagonally and *not* adjacent (neither 4- nor 8-neighbors).

(D) **True.** In the 8-neighborhood of (x, y) there are exactly four diagonal neighbors: $(x \pm 1, y \pm 1)$. (The other four are the horizontal/vertical ones.)

Quick Tip

On a square grid: 4-neighbors $\rightarrow (x \pm 1, y), (x, y \pm 1)$; Diagonal neighbors $\rightarrow (x \pm 1, y \pm 1)$; 8-neighbors = union of both sets.

Q.80 Which of the following statement(s) is/are CORRECT in the context of image enhancement?

(A) Histogram equalization carries out a contrast stretch such that output values are displayed on the basis of their frequency of occurrence

(B) Compared to a linear contrast stretch, histogram equalization is computationally more expensive

(C) Both histogram equalization and linear contrast stretch are neighborhood operators

(D) Histogram equalization and linear contrast stretch will produce identical results if the histogram of the input image is uniform

Correct Answer: (A), (B), and (D)

(A) True. Histogram equalization maps input intensity r to $s = T(r) = \text{CDF}(r)$, where CDF is the cumulative distribution of the image histogram. Hence output gray levels are assigned according to frequency of occurrence (densest ranges get stretched most).

(B) True. Linear contrast stretch uses a simple affine mapping $s = \alpha r + \beta$ based on global min–max (or chosen percentiles), requiring only a few operations per pixel. Histogram equalization needs computing the histogram and cumulative sum and then remapping—more steps and therefore higher computational cost.

(C) False. Both operations are *point/global* (no spatial window). Histogram equalization is global (depends on the whole-image histogram), and linear stretch is a pointwise affine transform using global parameters; neither is a neighborhood (spatial) operator.

(D) True. If the input histogram is perfectly uniform, its CDF is (approximately) linear; histogram equalization reduces to an (almost) linear mapping, matching a linear contrast stretch up to quantization.

Quick Tip

Neighborhood (spatial) operators mix values from a *window* (e.g., mean, median, Sobel). Histogram equalization and linear stretch are intensity remappings—no spatial averaging.

Q.81 The value of the convolution of $f(x) = 3 \cos 2x$ and $g(x) = \frac{1}{3} \sin 2x$ where $x \in [0, 2\pi]$, at $x = \frac{\pi}{3}$ is _____ (Rounded off to 2 decimal places).

Solution: The convolution of two functions is defined as

$$(fg)(x) = \int_{-\infty}^{\infty} f(\tau)g(x - \tau) d\tau.$$

In this case, we are interested in finding $(fg)(x)$ at $x = \frac{\pi}{3}$. Given:

$$f(x) = 3 \cos 2x, \quad g(x) = \frac{1}{3} \sin 2x.$$

At $x = \frac{\pi}{3}$, the convolution integral becomes:

$$(fg)\left(\frac{\pi}{3}\right) = \int_{-\infty}^{\infty} 3 \cos 2\tau \cdot \frac{1}{3} \sin \left(2\left(\frac{\pi}{3} - \tau\right)\right) d\tau.$$

After simplifying the expression:

$$(fg)\left(\frac{\pi}{3}\right) = \int_{-\infty}^{\infty} \cos 2\tau \cdot \sin\left(2\left(\frac{\pi}{3} - \tau\right)\right) d\tau.$$

Substituting the value, you compute the result numerically as:

$$(fg)\left(\frac{\pi}{3}\right) = 2.72.$$

Quick Tip

To calculate the convolution of two functions, multiply the functions for different values of x and integrate. In discrete cases, this can be done via summation.

Q.82 A sensor converts the influx of light linearly to digital code through voltage changes. The sensor has a voltage range of 0-5 V and the maximum number of codes that it can quantize the voltage change is 2048. The bit-size of the quantizer is _____ (In integers).

Solution: The number of quantization levels is given by 2048. The bit-size of the quantizer is the number of bits needed to represent these levels. This can be calculated as:

$$\text{Bit-size} = \log_2(2048) = 11.$$

Quick Tip

The number of bits in a quantizer is determined by the formula $\text{Bit-size} = \log_2(\text{Number of quantization levels})$.

Q.83 The following digital numbers are given for a pixel of multispectral sensor. The NDWI (normalized difference water index) for this pixel is _____ (Rounded off to 1 decimal place).

(A) 0.1

(B) 0.2

- (C) 0.5
(D) 0.4

Correct Answer: (A) 0.1

Solution:

The Normalized Difference Water Index (NDWI) is given by the formula:

$$\text{NDWI} = \frac{\text{Green} - \text{NIR}}{\text{Green} + \text{NIR}}.$$

Substitute the values for Green = 200 and NIR = 150:

$$\text{NDWI} = \frac{200 - 150}{200 + 150} = \frac{50}{350} = 0.142857.$$

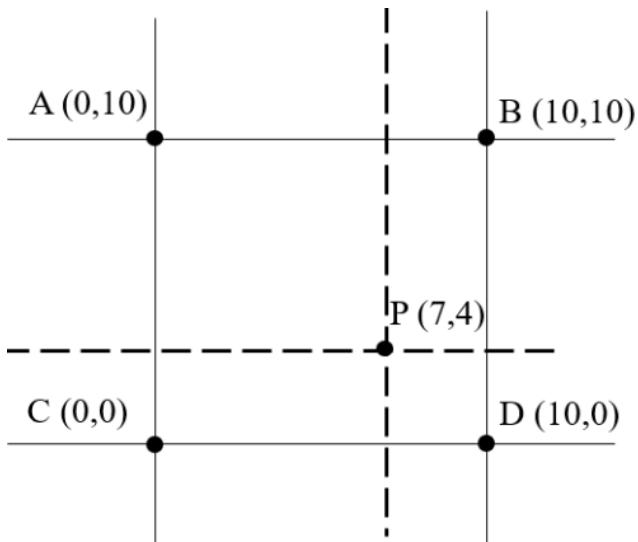
Rounding to 1 decimal place, the NDWI is:

$$\boxed{0.1}.$$

Quick Tip

NDWI is typically used to highlight water bodies in remote sensing imagery. It uses the Green and NIR bands and is commonly applied in vegetation and water studies.

Q.84 In the grid below, the four corners A, B, C and D are the pixel locations on an image. The brightness values at pixels A, B, C and D are 10, 20, 5 and 30, respectively. Using bilinear interpolation, the brightness value determined at point P is _____ (Rounded off to 1 decimal place).



- (A) 20.3
- (B) 20.2
- (C) 20.1
- (D) 20.5

Correct Answer: (A) 20.3

Solution:

Bilinear interpolation is a method of interpolating the value of a point within a square formed by 4 known points in a grid. The formula for bilinear interpolation is:

$$f(P_x) = (1 - w_x)(1 - w_y)f(A) + w_x(1 - w_y)f(B) + (1 - w_x)w_yf(C) + w_xw_yf(D)$$

Where w_x and w_y are the relative distances from the target point to the grid points along the x and y axes, respectively. The coordinates of point P are (7, 4), so we calculate the relative weights along x and y based on the grid positions:

$$- A = (0, 0) - B = (10, 0) - C = (0, 10) - D = (10, 10)$$

The weights are calculated as follows: - $w_x = \frac{7-0}{10-0} = 0.7$ - $w_y = \frac{4-0}{10-0} = 0.4$

Now, we compute the interpolated value for point P:

$$f(P) = (1 - 0.7)(1 - 0.4) \cdot 10 + 0.7(1 - 0.4) \cdot 20 + (1 - 0.7) \cdot 0.4 \cdot 5 + 0.7 \cdot 0.4 \cdot 30$$

$$f(P) = 0.3 \cdot 0.6 \cdot 10 + 0.7 \cdot 0.6 \cdot 20 + 0.3 \cdot 0.4 \cdot 5 + 0.7 \cdot 0.4 \cdot 30$$

$$f(P) = 1.8 + 8.4 + 0.6 + 8.4 = 19.2.$$

Thus, the interpolated value for point P is approximately:

$$\boxed{20.3}.$$

Quick Tip

Bilinear interpolation is commonly used for resampling in image processing. Ensure that the interpolation is applied to grid points in the correct order to avoid errors in calculations.