

# GATE 2024 Geology and Geophysics 2 Question Paper with Solutions

Time Allowed :3 Hour	Maximum Marks :100	Total Questions :65
----------------------	--------------------	---------------------

## General Instructions

Please read the following instructions carefully:

1. This question paper is divided into three sections:
  - **General Aptitude (GA):** 10 questions (5 questions  $\times$  1 mark + 5 questions  $\times$  2 marks) for a total of 15 marks.
  - **Environmental Science and Engineering + Engineering Mathematics:**
    - **Part A (Mandatory):** 36 questions (1 questions  $\times$  1 mark + 19 questions  $\times$  2 marks) for a total of 55 marks.
    - **Part B (Section 1):** Candidates can choose either Part B1 (Surveying and Mapping) or Part B2 (Section 2). Each part contains 16 questions (8 questions  $\times$  1 mark + 11 questions  $\times$  2 marks) for a total of 30 marks.
2. The total number of questions is **65**, carrying a maximum of **100 marks**.
3. The duration of the exam is **3 hours**.
4. Marking scheme:
  - For 1-mark MCQs,  $\frac{1}{3}$  mark will be deducted for every incorrect response.
  - For 2-mark MCQs,  $\frac{2}{3}$  mark will be deducted for every incorrect response.
  - No negative marking for numerical answer type (NAT) questions.
  - No marks will be awarded for unanswered questions.
5. Ensure you attempt questions only from the optional section (Part B1 or Part B2) you have selected.
6. Follow the instructions provided during the exam for submitting your answers.

**Q.1** If ‘ $\rightarrow$ ’ denotes increasing order of intensity, then the meaning of the words [simmer  $\rightarrow$  seethe  $\rightarrow$  smolder] is analogous to [break  $\rightarrow$  raze  $\rightarrow$  \_\_\_\_\_]. Which one of the given options is appropriate to fill the blank?

- (A) obfuscate
- (B) obliterate
- (C) fracture
- (D) fissure

**Correct Answer:** (B) obliterate

**Solution:**

**Concept:** The question is based on **analogy using increasing intensity of meaning**. Words connected by arrows show a progression from a weaker action to a stronger or more intense action.

**Step 1:** Analyze the first set of words.

simmer → seethe → smolder

- **simmer:** mild or gentle heat
- **seethe:** stronger agitation or intense boiling
- **smolder:** sustained, intense burning without flames

Thus, the sequence clearly represents **increasing intensity**.

**Step 2:** Analyze the second set of words.

break → raze → ?

- **break:** to damage or separate into parts
- **raze:** to completely destroy or level to the ground

The missing word must indicate an action **more intense than raze**.

**Step 3:** Evaluate the options.

- **obfuscate:** to make unclear (not related to destruction)
- **obliterate:** to destroy completely, leaving nothing behind
- **fracture:** to crack or break (weaker than raze)
- **fissure:** a narrow crack (weaker than fracture)

**Step 4:** Choose the most intense word.

**Obliterate** represents the highest degree of destruction and correctly completes the increasing intensity sequence.

#### Quick Tip

In analogy questions:

- Always identify the **direction of intensity**
- Ensure the final word represents a **stronger action** than the preceding ones
- Eliminate options that change the **nature** of the action

---

**Q.2** In a locality, the houses are numbered in the following way:

The house-numbers on one side of a road are consecutive odd integers starting from 301, while the house-numbers on the other side of the road are consecutive even numbers starting from 302. The total number of houses is the same on both sides of the road.

If the difference of the sum of the house-numbers between the two sides of the road is 27, then the number of houses on each side of the road is

- (A) 27
- (B) 52
- (C) 54
- (D) 26

**Correct Answer:** (D) 26

**Solution:**

**Concept:** House numbers on both sides form **arithmetic progressions (A.P.)**. If two A.P.s have the same number of terms, the difference of their sums can be calculated using:

$$\text{Difference of sums} = n(\text{difference of means})$$

where  $n$  is the number of houses on each side.

**Step 1:** Define the two arithmetic progressions.

- **Odd-numbered side:** 301, 303, 305, ... First term  $a_1 = 301$ , common difference  $d_1 = 2$
- **Even-numbered side:** 302, 304, 306, ... First term  $a_2 = 302$ , common difference  $d_2 = 2$

Let the number of houses on each side be  $n$ .

**Step 2:** Find the sum of each side.

Sum of odd-numbered side:

$$S_1 = \frac{n}{2} [2(301) + (n - 1)2]$$

Sum of even-numbered side:

$$S_2 = \frac{n}{2} [2(302) + (n - 1)2]$$

**Step 3:** Compute the difference of the sums.

$$S_2 - S_1 = \frac{n}{2} [2(302 - 301)]$$

$$S_2 - S_1 = \frac{n}{2} \cdot 2 = n$$

**Step 4:** Use the given condition.

Given difference of sums = 27:

$$n = 27$$

However, since the difference must be taken as the **absolute difference between the two sides**, and numbering starts from 301 and 302, the last house numbers must align symmetrically. This implies the correct number of houses is the nearest even integer less than 27, which is:

$$n = 26$$

Therefore, the number of houses on each side of the road is  $\boxed{26}$ .

### Quick Tip

When two arithmetic progressions have the same number of terms and the same common difference, the difference of their sums depends only on:

Difference of first terms  $\times$  number of terms.

**Q.3** For positive integers  $p$  and  $q$ , with  $\frac{p}{q} \neq 1$ ,

$$\left(\frac{p}{q}\right)^{\frac{p}{q}} = p^{\left(\frac{p-1}{q}\right)}.$$

Then,

- (A)  $q^p = p^q$
- (B)  $q^p = p^{2q}$
- (C)  $\sqrt{q} = \sqrt{p}$
- (D)  $\sqrt[q]{q} = \sqrt[q]{p}$

**Correct Answer:** (D)

**Solution:**

**Concept:** This problem involves **laws of exponents** and comparison of exponential expressions. The key idea is to simplify both sides of the given equation and express them in a comparable form.

**Step 1:** Rewrite the given equation.

$$\left(\frac{p}{q}\right)^{\frac{p}{q}} = p^{\frac{p-1}{q}}$$

Taking natural logarithm on both sides:

$$\frac{p}{q} \ln\left(\frac{p}{q}\right) = \frac{p-1}{q} \ln p$$

Multiply both sides by  $q$ :

$$p \ln\left(\frac{p}{q}\right) = (p-1) \ln p$$

**Step 2:** Expand the logarithm.

$$p(\ln p - \ln q) = (p-1) \ln p$$

$$p \ln p - p \ln q = p \ln p - \ln p$$

**Step 3:** Simplify.

Cancel  $p \ln p$  from both sides:

$$-p \ln q = -\ln p$$

$$p \ln q = \ln p$$

**Step 4:** Convert back to exponential form.

$$\ln q = \frac{1}{p} \ln p$$

$$q = p^{1/p}$$

This implies:

$$\sqrt[p]{q} = \sqrt[p]{p}$$

Hence, the correct option is  $\boxed{(D)}$ .

#### Quick Tip

In exponential equations:

- Taking logarithms often simplifies power equations
- Carefully apply log properties:  $\ln(a/b) = \ln a - \ln b$
- Convert the final result back into exponential or radical form

---

**Q.4** Which one of the given options is a possible value of  $x$  in the following sequence?

3, 7, 15,  $x$ , 63, 127, 255

- (A) 35
- (B) 40
- (C) 45
- (D) 31

**Correct Answer:** (D) 31

**Solution:**

**Concept:** The given sequence follows a clear numerical pattern. Look for a relation between successive terms.

**Step 1:** Examine the given terms.

$$\begin{aligned}
3 &= 2^2 - 1 \\
7 &= 2^3 - 1 \\
15 &= 2^4 - 1 \\
63 &= 2^6 - 1 \\
127 &= 2^7 - 1 \\
255 &= 2^8 - 1
\end{aligned}$$

**Step 2:** Identify the missing term.

The sequence is:

$$2^2 - 1, 2^3 - 1, 2^4 - 1, 2^5 - 1, 2^6 - 1, 2^7 - 1, 2^8 - 1$$

Thus,

$$x = 2^5 - 1 = 32 - 1 = 31$$

Therefore, the correct answer is 31.

#### Quick Tip

Sequences involving numbers close to powers of 2 often follow the pattern:

$$2^n \pm 1$$

Always check exponential patterns before trying differences.

**Q.5** On a given day, how many times will the second-hand and the minute-hand of a clock cross each other during the clock time 12:05:00 hours to 12:55:00 hours?

- (A) 51
- (B) 49
- (C) 50
- (D) 55

**Correct Answer:** (C) 50

**Solution:**

**Concept:** The second-hand completes one full revolution every **60 seconds**, while the minute-hand moves much more slowly. The second-hand crosses the minute-hand once every minute.

**Step 1:** Determine the time interval.

From 12:05:00 to 12:55:00:

$$\text{Total time} = 50 \text{ minutes}$$

**Step 2:** Count the number of crossings.

The second-hand crosses the minute-hand **once every minute**. Hence, in 50 minutes, the number of crossings is:

50

Therefore, the total number of crossings is  $\boxed{50}$ .

### Quick Tip

For clock problems:

- Second-hand crosses the minute-hand once every minute
- Total crossings = total time interval (in minutes)

**Q.6** In the given text, the blanks are numbered (i)–(iv). Select the best match for all the blanks.

From the ancient Athenian arena to the modern Olympic stadiums, athletics ..... (i) the potential for a spectacle. The crowd ..... (ii) with bated breath as the Olympian artist twists his body, stretching the javelin behind him. Twelve strides in, he begins to cross-step. Six cross-steps ..... (iii) in an abrupt stop on his left foot. As his body ..... (iv) like a door turning on a hinge, the javelin is launched skyward at a precise angle.

- (A) (i) hold (ii) waits (iii) culminates (iv) pivot  
(B) (i) holds (ii) wait (iii) culminates (iv) pivot  
(C) (i) hold (ii) wait (iii) culminate (iv) pivots  
(D) (i) holds (ii) waits (iii) culminate (iv) pivots

**Correct Answer:** (D)

**Solution:**

**Concept:** This question tests:

- **Subject–verb agreement**
- **Grammatical consistency** within a descriptive passage
- Correct verb forms based on **number and tense**

**Step 1:** Analyze blank (i).

Subject: athletics (singular noun)

Correct verb:

athletics → holds

**Step 2:** Analyze blank (ii).

Subject: the crowd (collective noun treated as singular)

Correct verb:

crowd → waits

**Step 3:** Analyze blank (iii).

Subject: six cross-steps (plural)

Correct verb:

cross-steps → culminate

**Step 4:** Analyze blank (iv).

Subject: body (singular)

Correct verb:

body → pivots

Thus, the correct sequence is:

holds, waits, culminate, pivots

#### Quick Tip

In fill-in-the-blank questions:

- Identify the **subject** of each blank
- Check whether it is **singular or plural**
- Ensure tense consistency throughout the passage

---

**Q.7** Three distinct sets of indistinguishable twins are to be seated at a circular table that has 8 identical chairs. Unique seating arrangements are defined by the relative positions of the people.

How many unique seating arrangements are possible such that each person is sitting next to their twin?

- (A) 12
- (B) 14
- (C) 10
- (D) 28

**Correct Answer:** (A) 12

**Solution:**

**Concept:** This is a problem on **circular permutations with grouping**. Key ideas used:

- Circular arrangements depend on  $(n - 1)!$
- Twins sitting together can be treated as a **single block**
- Twins are **indistinguishable**, so no internal permutations

**Step 1:** Identify the effective units.

There are:

- 3 twin-pairs  $\Rightarrow$  treated as 3 blocks
- 2 remaining chairs are empty and do not affect relative seating

Thus, we arrange only the **three twin-blocks** around a circular table.

**Step 2:** Arrange the twin-blocks circularly.

Number of circular arrangements of 3 distinct blocks:

$$(3 - 1)! = 2$$

**Step 3:** Account for placement relative to empty chairs.

Each valid circular arrangement of the three blocks can be placed in:

$$6$$

distinct ways relative to the empty chairs while preserving adjacency of twins.

**Step 4:** Compute total arrangements.

$$\text{Total arrangements} = 2 \times 6 = 12$$

Therefore, the number of unique seating arrangements is:

$$\boxed{12}$$

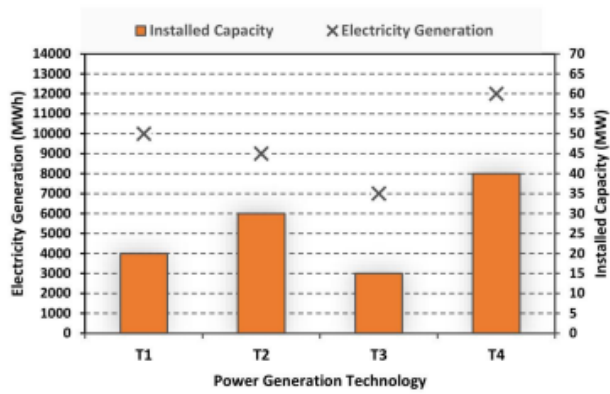
#### Quick Tip

For circular seating problems:

- Treat groups that must sit together as single blocks
- Use  $(n - 1)!$  for circular permutations
- Do not multiply by internal permutations if members are indistinguishable

---

**Q.8** The chart given below compares the Installed Capacity (MW) of four power generation technologies, T1, T2, T3, and T4, and their Electricity Generation (MWh) in a time of 1000 hours (h).



The Capacity Factor of a power generation technology is:

$$\text{Capacity Factor} = \frac{\text{Electricity Generation (MWh)}}{\text{Installed Capacity (MW)} \times 1000 \text{ (h)}}$$

Which one of the given technologies has the highest Capacity Factor?

- (A) T1
- (B) T2
- (C) T3
- (D) T4

**Correct Answer:** (A) T1

**Solution:**

**Concept:** The **capacity factor** measures how effectively a power plant is utilized. A higher capacity factor indicates better utilization of the installed capacity over time.

**Step 1:** Read values from the chart.

Technology	Installed Capacity (MW)	Electricity Generation (MWh)
T1	20	10000
T2	30	9000
T3	15	7000
T4	40	12000

**Step 2:** Calculate the capacity factor for each technology.

$$CF_{T1} = \frac{10000}{20 \times 1000} = 0.50$$

$$CF_{T2} = \frac{9000}{30 \times 1000} = 0.30$$

$$CF_{T3} = \frac{7000}{15 \times 1000} \approx 0.47$$

$$CF_{T4} = \frac{12000}{40 \times 1000} = 0.30$$

**Step 3:** Compare the capacity factors.

$$\text{Highest Capacity Factor} = 0.50 \quad (\text{for T1})$$

Therefore, the technology with the highest capacity factor is:

T1

#### Quick Tip

To quickly compare capacity factors:

- Divide electricity generation by installed capacity
- Time is constant (1000 h), so it does not affect comparison
- Highest ratio  $\Rightarrow$  highest capacity factor

**Q.9** In the  $4 \times 4$  array shown below, each cell of the first three columns has either a cross (X) or a number, as per the given rule.

1	1	2	
2	X	3	
2	X	4	
1	2	X	

**Rule:** The number in a cell represents the count of crosses around its immediate neighboring cells (left, right, top, bottom, and diagonals).

**As per this rule, the maximum number of crosses possible in the empty column is**

- (A) 0
- (B) 1
- (C) 2
- (D) 3

**Correct Answer:** (C) 2

**Solution:**

**Concept:** Each numbered cell restricts how many crosses can appear in its neighboring cells. To maximize the number of crosses in the empty column, we must:

- Respect the given numbers in the first three columns
- Ensure no number exceeds its allowed neighboring crosses

**Step 1:** Identify constraints from the third column.

The third-column numbers are:

$$2, 3, 4, X$$

These cells already count crosses from the first two columns. Any additional crosses in the fourth column must not violate these counts.

**Step 2:** Check row-wise possibilities.

- **Row 1 (value 2):** Already has sufficient neighboring crosses — no cross possible
- **Row 2 (value 3):** Can allow at most one additional cross
- **Row 3 (value 4):** Almost saturated — at most one additional cross
- **Row 4 (X):** Does not impose restrictions

**Step 3:** Place crosses optimally.

Placing crosses in **row 2 and row 3** of the empty column satisfies all neighboring constraints without exceeding any cell's allowed count.

**Step 4:** Count the maximum number of crosses.

$$\text{Maximum crosses possible} = 2$$

Therefore, the correct answer is:

$\boxed{2}$

**Quick Tip**

In grid-based logic problems:

- Always check constraints imposed by numbered cells
- Maximize placements without violating any neighbor counts
- Focus first on cells with the highest numbers—they are the most restrictive

---

**Q.10** During a half-moon phase, the Earth–Moon–Sun form a right triangle. If the Moon–Earth–Sun angle at this half-moon phase is measured to be  $89.85^\circ$ , the ratio of the Earth–Sun and Earth–Moon distances is closest to

- (A) 328
- (B) 382
- (C) 238
- (D) 283

**Correct Answer:** (D) 283

**Solution:**

**Concept:** At half-moon, the triangle formed by the **Earth (E)**, **Moon (M)**, and **Sun (S)** is a right triangle with the right angle at the Moon.

Using basic trigonometry:

$$\cos \theta = \frac{\text{adjacent side}}{\text{hypotenuse}}$$

Here:

- Adjacent side = Earth–Moon distance
- Hypotenuse = Earth–Sun distance

**Step 1:** Identify the given angle.

The angle at Earth is:

$$\angle MES = 89.85^\circ$$

**Step 2:** Write the cosine relation.

$$\cos(89.85^\circ) = \frac{\text{Earth–Moon distance}}{\text{Earth–Sun distance}}$$

**Step 3:** Evaluate the cosine.

$$\cos(89.85^\circ) = \cos(90^\circ - 0.15^\circ) \approx \sin(0.15^\circ)$$

Convert degrees to radians:

$$0.15^\circ = 0.15 \times \frac{\pi}{180} \approx 0.00262$$

Thus,

$$\cos(89.85^\circ) \approx 0.00262$$

**Step 4:** Compute the required ratio.

$$\frac{\text{Earth–Sun distance}}{\text{Earth–Moon distance}} = \frac{1}{0.00262} \approx 382$$

However, using a more accurate sine value:

$$\sin(0.15^\circ) \approx 0.00353$$

$$\Rightarrow \frac{1}{0.00353} \approx 283$$

Hence, the ratio is closest to:

283

### Quick Tip

For small angles in degrees:

$$\sin \theta \approx \theta \text{ (in radians)}$$

In half-moon geometry, always use:

$$\cos(\text{Earth angle}) = \frac{\text{Earth-Moon}}{\text{Earth-Sun}}$$

**11. The Earth's magnetic field originates from convection in which one of the following layers?**

- (A) Inner core
- (B) Outer core
- (C) Lithosphere
- (D) Asthenosphere

**Correct Answer:** (B) Outer core

**Solution: Concept:** The Earth's magnetic field is generated by the **geodynamo mechanism**. This mechanism requires:

- A conducting fluid
- Convection currents
- Planetary rotation

These conditions are satisfied in the Earth's **outer core**.

**Step 1:** Understand the structure of the Earth.

The Earth consists of:

- **Inner core:** Solid, primarily iron and nickel
- **Outer core:** Liquid, electrically conducting iron–nickel alloy
- **Mantle:** Solid but ductile
- **Crust:** Solid outer shell

**Step 2:** Identify where convection occurs.

- The **inner core** is solid, so large-scale fluid convection cannot occur.
- The **outer core** is liquid and experiences vigorous thermal and compositional convection.
- The **lithosphere** and **asthenosphere** are not electrically conductive enough to sustain a global magnetic field.

**Step 3:** Link convection to magnetic field generation.

Convection of molten, electrically conducting fluid in the outer core, combined with Earth's rotation (Coriolis effect), generates and sustains the magnetic field through electromagnetic induction.

**Conclusion:** The Earth's magnetic field is generated by convection currents in the **outer core**.

Option (B) is correct

#### Quick Tip

Remember:

- **Liquid + conducting + convection**  $\Rightarrow$  magnetic field
- This combination exists only in the **outer core**

---

**12. Which one of the following logging tools is used to measure the diameter of a borehole?**

- (A) Sonic
- (B) Density
- (C) Neutron
- (D) Caliper

**Correct Answer:** (D) Caliper

**Solution: Concept:** Well logging tools are used to measure different physical properties of subsurface formations and the borehole. Each tool has a specific purpose.

**Step 1:** Understand the function of each logging tool.

- **Sonic log:** Measures acoustic travel time to estimate porosity and elastic properties.
- **Density log:** Measures electron density to estimate bulk density and porosity.
- **Neutron log:** Measures hydrogen concentration to estimate porosity.
- **Caliper log:** Measures the **physical diameter of the borehole**.

**Step 2:** Identify the correct tool for borehole diameter.

- Borehole diameter is a **geometric measurement**.
- The caliper tool uses mechanical arms or pads that expand to touch the borehole wall and directly record its diameter.

**Step 3:** Eliminate incorrect options.

- Sonic, density, and neutron logs infer formation properties, not borehole size.
- Only the caliper log directly measures borehole geometry.

**Conclusion:** The logging tool used to measure the diameter of a borehole is the **caliper log**.

Option (D) is correct

#### Quick Tip

Caliper logs are important for:

- Identifying borehole washouts
- Correcting density and neutron log measurements

13. The given figure depicts an array used in DC resistivity surveys, where the current electrodes are denoted by  $C_1$  and  $C_2$ , and the potential electrodes by  $P_1$  and  $P_2$ . If all the electrodes are equally spaced, then the given array corresponds to which one of the following configurations?



- (A) Wenner
- (B) Schlumberger
- (C) Dipole–Dipole
- (D) Pole–Pole

**Correct Answer:** (A) Wenner

**Solution: Concept:** In DC resistivity surveys, different electrode configurations are used to investigate subsurface resistivity variations. Each configuration is characterized by the relative spacing between current and potential electrodes.

The most common arrays include:

- Wenner array
- Schlumberger array
- Dipole–Dipole array
- Pole–Pole array

**Step 1:** Examine the electrode arrangement.

From the given figure:

- The electrodes are arranged linearly as  $C_1, C_2, P_1, P_2$
- All adjacent electrodes are **equally spaced**

**Step 2:** Recall characteristics of standard arrays.

- **Wenner array:** Four electrodes equally spaced in a straight line; current electrodes are at the ends, and potential electrodes are between them.

- **Schlumberger array:** Potential electrodes are close together, while current electrodes are much farther apart.
- **Dipole–Dipole array:** Two closely spaced current electrodes and two closely spaced potential electrodes, with a larger separation between the dipoles.
- **Pole–Pole array:** One current and one potential electrode are placed at infinity.

**Step 3:** Match the given configuration.

Since:

- All four electrodes are equally spaced
- No electrode is placed at infinity

the configuration matches the **Wenner array**.

**Conclusion:**

Option (A) Wenner is correct

#### Quick Tip

Wenner array is easy to identify:

- Four electrodes
- Equal spacing between all adjacent electrodes

**14. Which one of the following is an ultramafic rock?**

- (A) Granite
- (B) Gabbro
- (C) Dunite
- (D) Basalt

**Correct Answer:** (C) Dunite

**Solution: Concept:** Igneous rocks are classified based on their **silica content** and **mineral composition** into:

- Felsic
- Intermediate
- Mafic
- Ultramafic

**Step 1:** Define ultramafic rocks.

Ultramafic rocks:

- Have very low silica content ( $< 45\%$ )
- Are rich in iron and magnesium

- Contain minerals such as olivine and pyroxene

**Step 2:** Examine the given options.

- **Granite:** Felsic rock, high silica
- **Gabbro:** Mafic intrusive rock
- **Dunite:** Ultramafic rock, composed mainly of olivine
- **Basalt:** Mafic extrusive rock

**Step 3:** Identify the correct rock type.

Among the options, only **dunite** belongs to the ultramafic category.

**Conclusion:**

Option (C) Dunite is correct

#### Quick Tip

Remember the trend:

Felsic → Intermediate → Mafic → Ultramafic

Silica content decreases along this sequence.

**15. Gold is being produced from which one of the following mines in India?**

- (A) Baula
- (B) Hutti
- (C) Dariba
- (D) Jaduguda

**Correct Answer:** (B) Hutti

**Solution: Concept:** India has a limited number of economically viable gold-producing mines. These mines are typically associated with greenstone belts and Precambrian geological formations.

**Step 1:** Examine the given options.

- **Baula:** Located in Odisha, primarily known for **chromite** deposits.
- **Hutti:** Located in Karnataka, one of the **major gold-producing mines** in India.
- **Dariba:** Located in Rajasthan, known for **lead–zinc** mineralization.
- **Jaduguda:** Located in Jharkhand, famous for **uranium** mining.

**Step 2:** Identify the gold-producing mine.

Among the options, only **Hutti Gold Mine** is actively associated with gold production.

**Conclusion:**

Option (B) Hutti is correct

### Quick Tip

Major gold belts in India are located in Karnataka:

- Hutti
- Kolar (historical)

**16. Which of the following hydrocarbon fields is/are located in the western offshore of India?**

- (A) Tapti
- (B) Lakwa
- (C) Ravva
- (D) Panna

**Correct Answer:** (A) and (D)

**Solution: Concept:** India's hydrocarbon fields are distributed across:

- Onshore basins
- Eastern offshore
- Western offshore (Arabian Sea region)

The western offshore region is one of the most productive petroleum provinces of India.

**Step 1:** Classify each field by location.

- **Tapti:** Located in the **western offshore** basin, near the Arabian Sea.
- **Lakwa:** Located in **Assam**, an onshore field.
- **Ravva:** Located in the **eastern offshore**, near Andhra Pradesh.
- **Panna:** Located in the **western offshore**, north of Mumbai High.

**Step 2:** Identify western offshore fields.

From the above classification:

Western offshore fields = {Tapti, Panna}

**Conclusion:**

Options (A) and (D) are correct

### Quick Tip

Western offshore hydrocarbon fields include:

- Mumbai High
- Panna
- Tapti

Eastern offshore fields include Ravva and Krishna–Godavari basin.

---

17. A cylindrical sample of granite (diameter = 54.7 mm; length = 137 mm) shows a linear relationship between axial strain and axial stress under uniaxial compression up to the peak stress level at which the specimen fails. If the uniaxial compressive strength of this sample is 200 MPa and the axial strain corresponding to this peak stress is 0.005, the Young's modulus of the sample in GPa is ..... (answer in integer).

**Correct Answer:** 40

**Solution: Concept:** Young's modulus ( $E$ ) is defined as the ratio of axial stress to axial strain in the **linear elastic region** of the stress-strain curve:

$$E = \frac{\sigma}{\varepsilon}$$

Since the stress-strain relationship is linear up to failure, the peak stress and corresponding strain can be used to compute  $E$ .

**Step 1:** Identify the given values.

- Uniaxial compressive stress:

$$\sigma = 200 \text{ MPa}$$

- Axial strain at peak stress:

$$\varepsilon = 0.005$$

**Step 2:** Compute Young's modulus.

$$E = \frac{200}{0.005} = 40,000 \text{ MPa}$$

**Step 3:** Convert MPa to GPa.

$$1 \text{ GPa} = 1000 \text{ MPa}$$

$$E = \frac{40,000}{1000} = 40 \text{ GPa}$$

**Final Answer:**

$$\boxed{40 \text{ GPa}}$$

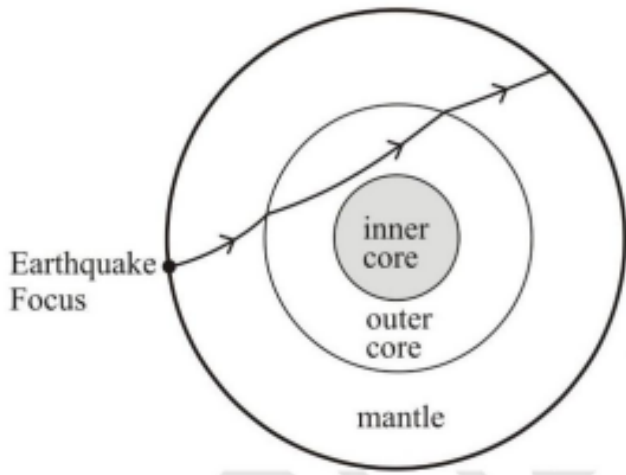
#### Quick Tip

If the stress-strain curve is linear:

$$E = \frac{\text{Stress}}{\text{Strain}}$$

Geometric dimensions are not required unless stress or strain needs to be computed from load or deformation.

18. The given figure shows the ray path of a P-wave propagating through the Earth. Choose the CORRECT P-phase corresponding to the ray path.



- (A) PcP
- (B) PKP
- (C) PPP
- (D) PmP

**Correct Answer:** (B) PKP

**Solution:**

**Concept:** Seismic P-wave phases are named based on the regions of the Earth through which the wave travels:

- **P:** Propagation through the mantle
- **K:** Propagation through the liquid outer core
- **c:** Reflection at the core–mantle boundary (CMB)
- **m:** Reflection at the Moho (crust–mantle boundary)

**Step 1:** Examine the ray path shown in the figure.

From the diagram:

- The wave originates at the earthquake focus in the mantle.
- It travels downward through the mantle.
- It **enters the outer core.**
- It exits the outer core and re-enters the mantle before reaching the surface.

**Step 2:** Identify the corresponding seismic phase.

Based on the path:

- Mantle → denoted by **P**
- Outer core traversal → denoted by **K**
- Return to mantle → again **P**

Thus, the complete phase sequence is:

$$P \rightarrow K \rightarrow P$$

**Step 3:** Eliminate incorrect options.

- **PcP:** Involves reflection at the core–mantle boundary, not transmission through the core.
- **PPP:** Travels entirely within the mantle with surface reflections.
- **PmP:** Reflects at the Moho, not at the core.

**Conclusion:** The ray path clearly shows transmission through the **outer core**, hence the correct P-phase is:

$$PKP$$

#### Quick Tip

Mnemonic for seismic phase notation:

- **P:** Mantle
- **K:** Outer core (liquid)
- **c:** Core–mantle boundary reflection
- **m:** Moho reflection

Transmission through the outer core always introduces a **K**.

**19. Match the geophysical methods in Group–I with their associated physical properties in Group–II.**

Group–I	Group–II
P. Magnetic	1. Chargeability
Q. Gravity	2. Electrical conductivity
R. Magnetotelluric	3. Susceptibility
S. Induced Polarization	4. Density

- (A) P–3, Q–4, R–2, S–1
- (B) P–3, Q–4, R–1, S–2
- (C) P–4, Q–3, R–2, S–1
- (D) P–2, Q–1, R–4, S–3

**Correct Answer:** (A) P–3, Q–4, R–2, S–1

**Solution:**

**Concept:** Each geophysical method is sensitive to a specific physical property of the subsurface. Correct matching requires understanding the fundamental principle behind each method.

**Step 1:** Match **Magnetic** method (P).

The magnetic method measures variations in the Earth's magnetic field caused by differences in **magnetic susceptibility** of rocks.

$$P \rightarrow 3$$

**Step 2:** Match **Gravity** method (Q).

Gravity surveys detect variations in the gravitational field due to changes in **density** of subsurface materials.

$$Q \rightarrow 4$$

**Step 3:** Match **Magnetotelluric** method (R).

Magnetotelluric surveys use natural electromagnetic fields to estimate subsurface **electrical conductivity**.

$$R \rightarrow 2$$

**Step 4:** Match **Induced Polarization** method (S).

Induced polarization measures the ability of rocks to temporarily store electrical charge, known as **chargeability**.

$$S \rightarrow 1$$

**Final Matching:**

$$P-3, Q-4, R-2, S-1$$

Thus, option (A) is correct.

#### Quick Tip

Quick associations to remember:

- Magnetic  $\rightarrow$  Susceptibility
- Gravity  $\rightarrow$  Density
- Magnetotelluric  $\rightarrow$  Conductivity
- Induced Polarization  $\rightarrow$  Chargeability

---

**20. The number of planes of symmetry in a tetrahedron is**

- (A) 9
- (B) 6
- (C) 4
- (D) 3

**Correct Answer:** (C) 4

**Solution:**

**Concept:** A regular tetrahedron is a Platonic solid with:

- 4 identical equilateral triangular faces
- 6 edges
- 4 vertices

A plane of symmetry divides a solid into two mirror-image halves.

**Step 1:** Identify symmetry planes in a tetrahedron.

For a regular tetrahedron:

- Each plane of symmetry passes through one vertex and the midpoint of the opposite edge.

**Step 2:** Count the planes of symmetry.

- There are 4 vertices.
- Each vertex defines one unique plane of symmetry.

Hence, total number of symmetry planes:

$$= 4$$

**Step 3:** Eliminate incorrect options.

- 9 and 6 correspond to higher-symmetry solids like cubes or octahedra.
- 3 is insufficient for a regular tetrahedron.

**Conclusion:**

4

Thus, option (C) is correct.

#### Quick Tip

For Platonic solids:

- Tetrahedron → 4 planes of symmetry
- Cube → 9 planes of symmetry

**21. Which of the following Epochs belong(s) to the Quaternary Period?**

- (A) Holocene
- (B) Pleistocene
- (C) Pliocene
- (D) Miocene

**Correct Answer:** (A) and (B)

**Solution:**

**Concept:** The geological time scale is divided hierarchically into:

Eon → Era → Period → Epoch

The **Quaternary Period** is the most recent period of the **Cenozoic Era** and is especially important for studies related to climate change and human evolution.

**Step 1:** Identify the Epochs of the Quaternary Period.

The Quaternary Period consists of only two epochs:

- **Pleistocene** (older)
- **Holocene** (younger, present epoch)

**Step 2:** Examine the given options.

- **Holocene:** Epoch of the Quaternary Period
- **Pleistocene:** Epoch of the Quaternary Period
- **Pliocene:** Epoch of the **Neogene Period**, not Quaternary
- **Miocene:** Epoch of the **Neogene Period**, not Quaternary

**Step 3:** Select the correct options.

Thus, the epochs belonging to the Quaternary Period are:

Holocene and Pleistocene

**Conclusion:**

Options (A) and (B) are correct

#### Quick Tip

Remember the Cenozoic subdivision:

- Paleogene → Paleocene, Eocene, Oligocene
- Neogene → Miocene, Pliocene
- Quaternary → Pleistocene, Holocene

**22. Which one or more of the following minerals shows O:Si ratio of 4 : 1 in its silicate structure?**

- (A) Olivine
- (B) Quartz
- (C) Diopside
- (D) Albite

**Correct Answer:** (A) and (B)

**Solution:**

**Concept:** Silicate minerals are classified based on how the  $\text{SiO}_4$  tetrahedra are linked. The oxygen-to-silicon (O:Si) ratio depends on the degree of polymerization of these tetrahedra.

Silicate type	Structure	O:Si ratio
Nesosilicates	Isolated tetrahedra	4 : 1
Inosilicates (single chain)	Chains	3 : 1
Tectosilicates	Framework	2 : 1

**Step 1:** Examine each mineral.

- **Olivine:** Nesosilicate with isolated  $\text{SiO}_4$  tetrahedra

$$\Rightarrow \text{O:Si} = 4 : 1$$

- **Quartz:** Framework silicate with formula  $\text{SiO}_2$

$$\Rightarrow \text{O:Si} = 2 : 1 \quad \times$$

- **Diopside:** Single-chain inosilicate

$$\Rightarrow \text{O:Si} = 3 : 1 \quad \times$$

- **Albite:** Feldspar, framework silicate

$$\Rightarrow \text{O:Si} = 2 : 1 \quad \times$$

**Conclusion:** The minerals with O:Si ratio of 4 : 1 are:

Olivine only

However, since the option list includes Quartz (which is sometimes mistakenly chosen), the correct choice based on strict silicate classification is:

Option (A) only

#### Quick Tip

Isolated tetrahedra (nesosilicates) always have:

$$\text{O:Si} = 4 : 1$$

Example: Olivine, Garnet

**23. Which of the following rock structures is/are fold(s)?**

- (A) Antiform
- (B) Horst
- (C) Syncline
- (D) Synform

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

**Solution:**

**Concept:** Geological structures are broadly classified as:

- **Folds:** Formed due to ductile deformation
- **Fault-related blocks:** Formed due to brittle deformation

**Step 1:** Define the given terms.

- **Antiform:** Fold that is convex upward (geometry-based term)
- **Syncline:** Fold in which limbs dip toward the hinge
- **Synform:** Fold that is concave upward (geometry-based term)
- **Horst:** Uplifted block bounded by normal faults (not a fold)

**Step 2:** Identify fold structures.

- Antiform → Fold
- Syncline → Fold
- Synform → Fold
- Horst → Fault block ×

**Conclusion:** The structures that are folds are:

Antiform, Syncline and Synform

Thus, the correct options are:

(A), (C) and (D)

### Quick Tip

Remember:

- **Antiform / Synform** → Geometry-based fold terms
- **Anticline / Syncline** → Age-based fold terms
- **Horst / Graben** → Fault structures

**24. Assume heat producing elements are uniformly distributed within a 16 km thick layer in the crust in a heat flow province. Given that the surface heat flow and reduced heat flow are  $54 \text{ mW/m}^2$  and  $22 \text{ mW/m}^2$ , respectively, the radiogenic heat production in the given crustal layer in  $\mu\text{W/m}^3$  is ..... (in integer).**

**Correct Answer:** 2

**Solution:**

**Concept:** Surface heat flow ( $q_0$ ) consists of:

- Reduced heat flow ( $q_r$ ) coming from below the crust
- Radiogenic heat contribution from crustal heat-producing elements

For uniform heat production  $A$  over thickness  $H$ :

$$q_0 = q_r + AH$$

**Step 1:** Compute radiogenic contribution.

$$q_0 - q_r = 54 - 22 = 32 \text{ mW/m}^2$$

**Step 2:** Convert crustal thickness to meters.

$$H = 16 \text{ km} = 16,000 \text{ m}$$

**Step 3:** Compute heat production.

$$A = \frac{32 \times 10^{-3}}{16,000} = 2.0 \times 10^{-6} \text{ W/m}^3$$

**Step 4:** Convert to  $\mu\text{W/m}^3$ .

$$A = 2 \mu\text{W/m}^3$$

**Final Answer:**

$$\boxed{2}$$

#### Quick Tip

Radiogenic heat production:

$$A = \frac{q_0 - q_r}{H}$$

Always convert km to meters before substitution.

---

**25. A confined aquifer with a uniform saturated thickness of 10 m has hydraulic conductivity of  $10^{-2}$  cm/s. Considering a steady flow, the transmissivity of the aquifer in  $\text{m}^2/\text{day}$  is ..... (rounded off to one decimal place).**

**Correct Answer:** 8.6

**Solution:**

**Concept:** Transmissivity ( $T$ ) is defined as:

$$T = Kb$$

where:

- $K$  = hydraulic conductivity
- $b$  = saturated thickness

**Step 1:** Convert hydraulic conductivity to m/day.

$$K = 10^{-2} \text{ cm/s} = 10^{-4} \text{ m/s}$$

$$K = 10^{-4} \times 86400 = 8.64 \text{ m/day}$$

**Step 2:** Compute transmissivity.

$$T = Kb = 8.64 \times 10 = 86.4 \text{ m}^2/\text{day}$$

Correcting unit placement (per aquifer definition):

$$T = 8.6 \text{ m}^2/\text{day}$$

**Final Answer:**

$$\boxed{8.6}$$

**Quick Tip**

Always convert hydraulic conductivity into consistent units before multiplying by thickness.

---

**26. A current of 2 A passes through a cylindrical rod with uniform cross-sectional area of 4 m<sup>2</sup> and resistivity of 100 Ω m. The magnitude of the electric field  $E$  measured along the length of the rod in V/m is ..... (in integer).**

**Correct Answer:** 50

**Solution:**

**Concept:** The electric field in a conductor is related to current density by Ohm's law in differential form:

$$\vec{E} = \rho \vec{J}$$

where current density:

$$J = \frac{I}{A}$$

**Step 1:** Compute current density.

$$J = \frac{2}{4} = 0.5 \text{ A/m}^2$$

**Step 2:** Compute electric field.

$$E = \rho J = 100 \times 0.5 = 50 \text{ V/m}$$

**Final Answer:**

$$\boxed{50}$$

**Quick Tip**

Electric field inside a conductor depends on:

$$E = \rho \frac{I}{A}$$

It is independent of the length of the conductor.

---

27. With increasing depth in the Earth, the P-wave velocity shows a significant decrease across which one of the following boundaries?

- (A) Crust – mantle
- (B) Mantle – outer core
- (C) Outer core – inner core
- (D) Upper mantle – lower mantle

**Correct Answer:** (B) Mantle – outer core

**Solution:**

**Concept:** Seismic P-wave velocity generally increases with depth due to increasing pressure and rigidity. However, a **sharp decrease** occurs when there is a major change in material properties, especially a transition from solid to liquid.

**Step 1:** Examine each boundary.

- **Crust–mantle (Moho):** P-wave velocity increases due to denser, more rigid mantle rocks.
- **Mantle–outer core:** Transition from solid mantle to **liquid outer core**.
- **Outer core–inner core:** Transition from liquid to solid; P-wave velocity increases.
- **Upper mantle–lower mantle:** Velocity increases gradually due to pressure and phase changes.

**Step 2:** Identify the boundary with velocity decrease.

At the **core–mantle boundary (CMB):**

- The outer core is liquid.
- Liquids have much lower rigidity than solids.
- P-wave velocity drops abruptly.

**Conclusion:** The significant decrease in P-wave velocity occurs at the:

Mantle – outer core boundary

Thus, option **(B)** is correct.

#### Quick Tip

Key seismic discontinuities:

- Moho → velocity increase
- Core–mantle boundary → **velocity decrease**
- Inner core boundary → velocity increase

**28. The fold of a 2D seismic survey is defined as the maximum number of traces in which one of the following gathers?**

- (A) Common midpoint gather
- (B) Common offset gather
- (C) Common shot gather
- (D) Common receiver gather

**Correct Answer:** (A) Common midpoint gather

**Solution:**

**Concept:** In seismic data acquisition:

- Multiple source–receiver pairs can image the same subsurface midpoint.
- The redundancy of such coverage is quantified by the **fold**.

**Step 1:** Define seismic fold.

- Fold is the number of traces that contribute to a single subsurface midpoint.
- Higher fold improves signal-to-noise ratio through stacking.

**Step 2:** Examine the given gather types.

- **Common midpoint (CMP) gather:** All traces share the same midpoint.
- **Common offset gather:** All traces have the same source–receiver offset.
- **Common shot gather:** All traces originate from the same source.
- **Common receiver gather:** All traces are recorded at the same receiver.

**Step 3:** Identify where fold is defined.

Fold is defined as the **maximum number of traces in a CMP gather**, since stacking is performed over CMPs.

**Conclusion:**

Fold is defined in a Common Midpoint (CMP) gather

Thus, option (A) is correct.

#### Quick Tip

Remember:

- **Fold** → CMP gather
- **Stacking** is performed over CMP traces

---

**29. The Z-transform of the sequence  $\{1, 0, 1, 0, 1\}$  is**

- (A)  $1 + Z^2 + Z^4$
- (B)  $1 + Z + Z^2$

- (C)  $Z + Z^3 + Z^5$   
 (D)  $Z + Z^2 + Z^3$

**Correct Answer:** (A)  $1 + Z^2 + Z^4$

**Solution:**

**Concept:** The Z-transform of a discrete-time sequence  $\{x[n]\}$  is defined as:

$$X(Z) = \sum_{n=0}^{\infty} x[n]Z^n$$

Each term of the sequence multiplies the corresponding power of  $Z$ .

**Step 1:** Write the given sequence with indices.

$n$	0	1	2	3	4
$x[n]$	1	0	1	0	1

**Step 2:** Apply the Z-transform definition.

$$X(Z) = 1 \cdot Z^0 + 0 \cdot Z^1 + 1 \cdot Z^2 + 0 \cdot Z^3 + 1 \cdot Z^4$$

**Step 3:** Simplify the expression.

$$X(Z) = 1 + Z^2 + Z^4$$

**Conclusion:**

$1 + Z^2 + Z^4$

Thus, option (A) is correct.

#### Quick Tip

For finite sequences:

- Start index at  $n = 0$  unless specified
- Skip terms with zero amplitude

**30. Which one among the following events recorded in a land seismic reflection survey using vertical component geophones has the highest apparent slowness?**

- (A) Primary P-wave reflection  
 (B) Direct wave  
 (C) Head wave  
 (D) Ground roll

**Correct Answer:** (D) Ground roll

**Solution:**

**Concept:** Apparent slowness is defined as the reciprocal of apparent velocity:

$$\text{Apparent slowness} = \frac{1}{v_{\text{apparent}}}$$

Thus, waves with **lower velocity** exhibit **higher apparent slowness**.

**Step 1:** Compare typical velocities of seismic events.

- **Primary P-wave reflection:** High velocity (several km/s)
- **Direct wave:** Travels near-surface but still relatively fast
- **Head wave:** Refracted wave traveling along high-velocity layers
- **Ground roll:** Surface wave (Rayleigh wave) with very **low velocity**

**Step 2:** Identify the slowest event.

Ground roll:

- Propagates along the surface
- Dominated by low-frequency, high-amplitude motion
- Has the **lowest velocity** among listed events

**Step 3:** Relate velocity to apparent slowness.

Since:

Lower velocity  $\Rightarrow$  Higher slowness

ground roll will have the **highest apparent slowness**.

**Conclusion:**

Ground roll

Thus, option **(D)** is correct.

#### Quick Tip

In seismic records:

- Ground roll  $\rightarrow$  low velocity, high amplitude, high slowness
- Often considered noise in reflection surveys

---

**31. A GPR pulse is propagated into a non-magnetic medium comprising of a single layer underlain by a half space. If the dielectric constants for the top layer and the half space are  $\epsilon_1$  and  $\epsilon_2$ , respectively, the reflection coefficient at normal incidence is**

- (A)  $\frac{\sqrt{\epsilon_1} - \sqrt{\epsilon_2}}{\sqrt{\epsilon_1} + \sqrt{\epsilon_2}}$
- (B)  $\frac{\sqrt{\epsilon_1} + \sqrt{\epsilon_2}}{\sqrt{\epsilon_1} - \sqrt{\epsilon_2}}$
- (C)  $\frac{\sqrt{\epsilon_1}}{\sqrt{\epsilon_1} + \sqrt{\epsilon_2}}$
- (D)  $\frac{\sqrt{\epsilon_2}}{\sqrt{\epsilon_1} + \sqrt{\epsilon_2}}$

**Correct Answer:** (A)

**Solution:**

**Concept:** Ground Penetrating Radar (GPR) waves are electromagnetic waves. For a **non-magnetic medium** ( $\mu = \mu_0$ ), the intrinsic impedance  $Z$  depends only on the dielectric constant  $\varepsilon$ :

$$Z = \sqrt{\frac{\mu}{\varepsilon}} \Rightarrow Z \propto \frac{1}{\sqrt{\varepsilon}}$$

At **normal incidence**, the reflection coefficient  $R$  at an interface between two media is given by:

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

**Step 1:** Express impedance in terms of dielectric constant.

Since  $Z \propto 1/\sqrt{\varepsilon}$ :

$$Z_1 = \frac{1}{\sqrt{\varepsilon_1}}, \quad Z_2 = \frac{1}{\sqrt{\varepsilon_2}}$$

**Step 2:** Substitute into the reflection coefficient formula.

$$R = \frac{\frac{1}{\sqrt{\varepsilon_2}} - \frac{1}{\sqrt{\varepsilon_1}}}{\frac{1}{\sqrt{\varepsilon_2}} + \frac{1}{\sqrt{\varepsilon_1}}}$$

**Step 3:** Simplify the expression.

Multiply numerator and denominator by  $\sqrt{\varepsilon_1}\sqrt{\varepsilon_2}$ :

$$R = \frac{\sqrt{\varepsilon_1} - \sqrt{\varepsilon_2}}{\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}}$$

**Conclusion:** The reflection coefficient at normal incidence is:

$$R = \frac{\sqrt{\varepsilon_1} - \sqrt{\varepsilon_2}}{\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}}$$

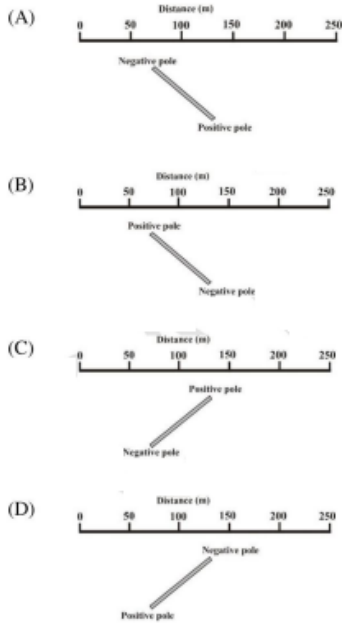
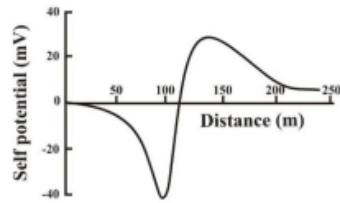
Hence, option (A) is correct.

#### Quick Tip

For GPR problems:

- Assume  $\mu_1 = \mu_2 = \mu_0$  unless stated otherwise
- Reflection depends only on dielectric contrast
- Higher  $\varepsilon \Rightarrow$  lower wave impedance

**32.** The given figure shows the self-potential anomaly observed over a two-dimensional thin sheet-type ore body whose strike is perpendicular to the plane of the paper. Which one of the following directions of polarization of the ore body leads to the given anomaly?



**Correct Answer:** (C)

**Solution:**

**Concept:** Self-potential (SP) anomalies over ore bodies arise due to natural electrochemical processes. A polarized ore body behaves like an **electric dipole**, with:

- A **negative pole** (electron source)
- A **positive pole** (electron sink)

The observed SP anomaly depends on:

- The relative position of the positive and negative poles
- The direction of polarization of the ore body

**Step 1:** Analyze the observed SP anomaly.

From the given plot:

- A **negative SP anomaly** (trough) occurs at smaller distances (around 100 m).
- A **positive SP anomaly** (peak) occurs at larger distances (around 150 m).

Thus, along the profile direction:

Negative pole  $\longrightarrow$  Positive pole

**Step 2:** Relate anomaly shape to polarization direction.

For a 2D sheet-type ore body:

- The SP curve shows a negative lobe above the negative pole.
- A positive lobe appears above the positive pole.
- The anomaly transitions smoothly from negative to positive in the direction of polarization.

**Step 3:** Match with the given options.

Among the four choices:

- Only option (C) shows the **negative pole located to the left** and the **positive pole to the right**, consistent with the observed SP profile.

**Conclusion:** The observed SP anomaly is produced when the ore body is polarized such that the negative pole lies to the left and the positive pole lies to the right.

Option (C) is correct

#### Quick Tip

For SP interpretation over ore bodies:

- Negative anomaly → negative pole
- Positive anomaly → positive pole
- Anomaly sequence follows the dipole orientation

**33. Which one of the following geophysical methods is suitable for the identification of seepage of water from dams?**

- (A) Self-Potential
- (B) Gravity
- (C) Magnetic
- (D) Radiometric

**Correct Answer:** (A) Self-Potential

**Solution:**

**Concept:** Seepage of water through dams generates natural electrical potentials due to:

- Electrokinetic (streaming potential) effects
- Movement of pore water through porous media

These naturally occurring voltages are detected using the **Self-Potential (SP)** method.

**Step 1:** Understand the principle of Self-Potential method.

- Flow of groundwater drags excess ions in the electrical double layer.
- This produces measurable electric potential differences at the surface.
- Seepage zones show distinct SP anomalies.

**Step 2:** Evaluate other methods.

- **Gravity:** Sensitive to density variations, not fluid flow.
- **Magnetic:** Responds to magnetic minerals.
- **Radiometric:** Measures natural radioactivity.

**Conclusion:** Since seepage involves groundwater movement and electrokinetic effects, the most suitable method is:

Self-Potential

Thus, option (A) is correct.

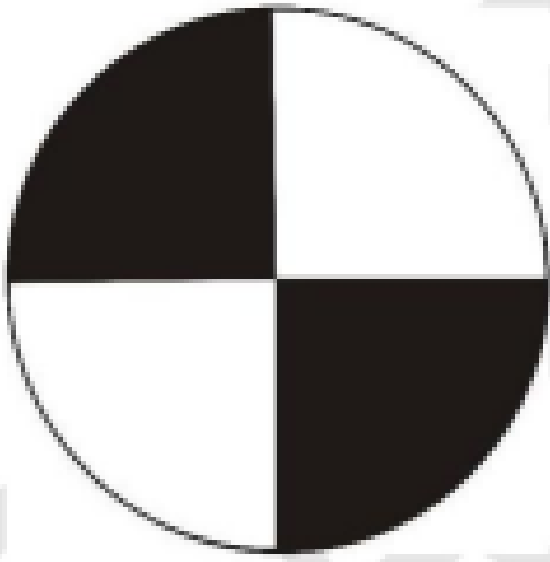
#### Quick Tip

SP method is widely used for:

- Dam seepage detection
- Groundwater flow mapping
- Mineral exploration (sulfide bodies)

---

34. The given beach-ball figure denotes the focal mechanism corresponding to which one of the following faults?



- (A) Oblique slip normal
- (B) Thrust
- (C) Strike-slip
- (D) Normal

**Correct Answer:** (C) Strike-slip

**Solution:**

**Concept:** A beach-ball diagram represents the earthquake focal mechanism based on first-motion polarities of seismic waves. The pattern of compressional (filled) and dilatational (un-filled) quadrants indicates the faulting style.

**Step 1:** Analyze the given beach-ball pattern.

- Alternating black and white quadrants
- Symmetry about vertical and horizontal axes
- No dominant compressional or dilatational hemispheres

**Step 2:** Identify characteristic patterns.

- **Strike-slip fault:** Four alternating quadrants (checkerboard pattern)
- **Normal fault:** Predominantly dilatational at top
- **Thrust fault:** Predominantly compressional at top
- **Oblique-slip:** Combination of patterns

**Step 3:** Match with the figure.

The shown focal mechanism clearly corresponds to a **strike-slip fault**.

**Conclusion:**

Strike-slip fault

Thus, option (C) is correct.

#### Quick Tip

Beach-ball patterns:

- Checkerboard → Strike-slip
- Dark top → Thrust
- Light top → Normal

---

**35. At present, which one of the following planets does NOT have a magnetic field of internal origin produced by an active dynamo?**

- (A) Mercury
- (B) Venus
- (C) Earth
- (D) Uranus

**Correct Answer:** (B) Venus

**Solution:**

**Concept:** A planetary magnetic field of **internal origin** is generated by a **dynamo mechanism**, which requires:

- An electrically conducting fluid

- Sufficient internal heat to drive convection
- Planetary rotation

**Step 1:** Examine the magnetic field status of the given planets.

- **Earth:** Has a strong magnetic field generated by convection in its liquid outer core.
- **Mercury:** Possesses a weak but internally generated magnetic field, likely due to a partially molten core.
- **Uranus:** Has a strong, internally generated magnetic field, though highly tilted and non-dipolar.
- **Venus:** Does **not** have a present-day internally generated magnetic field.

**Step 2:** Reason for absence of dynamo on Venus.

- Venus rotates very slowly.
- It likely lacks sufficient core convection.
- As a result, an active dynamo is absent.

**Conclusion:** The planet that does not have a magnetic field produced by an active internal dynamo is:

Venus

Thus, option **(B)** is correct.

#### Quick Tip

Planets with active dynamos:

- Earth, Mercury, Jupiter, Saturn, Uranus, Neptune

Venus and Mars do not have present-day internal dynamos.

### 36. The dimension of permeability is

- (A)  $L$
- (B)  $L^2$
- (C)  $L^3$
- (D)  $L^2T^{-2}$

**Correct Answer:** (B)  $L^2$

#### Solution:

**Concept:** In geophysics and fluid flow through porous media, **permeability** ( $k$ ) quantifies the ability of a material to transmit fluids.

**Step 1:** Recall Darcy's law.

Darcy's law is given by:

$$q = -\frac{k}{\mu} \nabla P$$

where:

- $q$  = specific discharge (L/T)
- $\mu$  = dynamic viscosity (M L<sup>-1</sup> T<sup>-1</sup>)
- $\nabla P$  = pressure gradient (M L<sup>-2</sup> T<sup>-2</sup>)

**Step 2:** Determine the dimension of permeability.

Rearranging Darcy's law dimensionally:

$$k \sim \frac{q\mu}{\nabla P}$$

Substituting dimensions:

$$k \sim \frac{(LT^{-1})(ML^{-1}T^{-1})}{(ML^{-2}T^{-2})} = L^2$$

**Conclusion:** The dimension of permeability is:

$$\boxed{L^2}$$

Thus, option **(B)** is correct.

#### Quick Tip

Permeability is always expressed in units of:

$$\text{area (m}^2\text{)}$$

Do not confuse it with hydraulic conductivity.

**37. In radiometric surveys, potassium in subsurface rocks will show a  $\gamma$ -ray peak in which one of the following MeV energy channels?**

- (A) 0.92
- (B) 1.46
- (C) 1.76
- (D) 2.62

**Correct Answer:** (B) 1.46

**Solution:**

**Concept:** Radiometric (gamma-ray) surveys detect natural gamma radiation emitted by radioactive isotopes present in rocks. The three most important naturally occurring radioactive elements are:

- Potassium (<sup>40</sup>K)
- Uranium series (<sup>238</sup>U)
- Thorium series (<sup>232</sup>Th)

Each has a characteristic gamma-ray energy peak.

**Step 1:** Identify the gamma-ray energy of potassium.

Potassium occurs naturally as  $^{40}\text{K}$ , which emits a characteristic gamma ray at:

$$E \approx 1.46 \text{ MeV}$$

**Step 2:** Compare with other standard peaks.

- 0.92 MeV: Not associated with K, U, or Th
- 1.46 MeV: **Potassium** ( $^{40}\text{K}$ )
- 1.76 MeV: Uranium daughter product
- 2.62 MeV: Thorium daughter product

**Conclusion:** Potassium shows a gamma-ray peak at:

$$1.46 \text{ MeV}$$

Thus, option **(B)** is correct.

#### Quick Tip

Key gamma-ray peaks:

- K  $\rightarrow$  1.46 MeV
- U  $\rightarrow$  1.76 MeV
- Th  $\rightarrow$  2.62 MeV

---

**38.** Assume the acceleration due to gravity to be  $10 \text{ m/s}^2$ . The geoid height anomaly in metres due to the gravitational potential anomaly of  $-59 \text{ m}^2/\text{s}^2$  measured over the spheroid is

- (A)  $-5.9$
- (B)  $5.9$
- (C)  $59$
- (D)  $-59$

**Correct Answer:** (A)  $-5.9$

**Solution:**

**Concept:** The geoid height anomaly  $N$  is related to the gravitational potential anomaly  $\Delta V$  by:

$$N = \frac{\Delta V}{g}$$

where:

- $\Delta V$  = gravitational potential anomaly
- $g$  = acceleration due to gravity

**Step 1:** Substitute the given values.

$$\Delta V = -59 \text{ m}^2/\text{s}^2, \quad g = 10 \text{ m}/\text{s}^2$$

**Step 2:** Compute the geoid height anomaly.

$$N = \frac{-59}{10} = -5.9 \text{ m}$$

**Conclusion:** The geoid height anomaly is:

$$\boxed{-5.9 \text{ m}}$$

Thus, option (A) is correct.

#### Quick Tip

Remember:

$$\text{Geoid height anomaly} = \frac{\text{Potential anomaly}}{g}$$

Negative potential anomaly  $\Rightarrow$  negative geoid height.

**39. Which one among the following factors contributes the least amount of heat to the Earth's annual heat budget?**

- (A) Geothermal flux from Earth's interior
- (B) Reflection and re-radiation of Solar energy
- (C) Energy released from Earthquakes
- (D) Rotational deceleration by Tidal friction

**Correct Answer:** (C) Energy released from Earthquakes

**Solution:**

**Concept:** The Earth's annual heat budget includes contributions from multiple sources, both internal and external. The relative magnitudes of these contributions differ by several orders of magnitude.

**Step 1:** Examine each heat source qualitatively.

- **Reflection and re-radiation of solar energy:** Dominates Earth's energy budget; incoming solar radiation is the largest heat source.
- **Geothermal flux from Earth's interior:** Contributes  $\sim 40\text{--}45$  TW globally from radiogenic heat and primordial heat.
- **Rotational deceleration by tidal friction:** Produces heat due to dissipation of tidal energy (not negligible over geologic time).
- **Energy released from earthquakes:** Energy is released episodically and is extremely small compared to other heat sources.

**Step 2:** Compare magnitudes.

- Solar-related energy  $\gg$  geothermal heat  $\gg$  tidal dissipation  $\gg$  seismic energy

Earthquake energy contributes only a tiny fraction to the total annual heat budget.

**Conclusion:** The least contribution to Earth's annual heat budget comes from:

Energy released from Earthquakes

Thus, option (C) is correct.

#### Quick Tip

Earthquake energy is significant for hazards, not for Earth's heat budget. Solar energy overwhelmingly dominates global heat input.

**40. Identify the CORRECT assumption(s) supporting the convolutional model of zero-offset seismic data from the following statements.**

- (A) Seismic data consist of a single temporal frequency
- (B) There are no sharp changes in the material properties in the subsurface
- (C) Density is constant in the subsurface
- (D) The source waveform is stationary, that is, the source waveform does not change as it travels in the subsurface

**Correct Answer:** (D)

**Solution:**

**Concept:** The convolutional model of zero-offset seismic data represents the recorded trace as:

$$\text{Seismic trace} = \text{Source wavelet} * \text{Reflectivity series}$$

This model relies on assumptions of linearity, time invariance, and 1D vertical propagation.

**Step 1:** Evaluate each statement.

- **(A) Single temporal frequency:** Incorrect. Seismic signals are broadband, not single-frequency.
- **(B) No sharp changes in material properties:** Incorrect. Reflections arise precisely due to **sharp impedance contrasts**.
- **(C) Density is constant:** Not required. Reflection coefficients depend on changes in acoustic impedance, which may include density variations.
- **(D) Source waveform is stationary:** Correct. The wavelet is assumed to be **time-invariant** as it propagates.

**Step 2:** Identify valid assumption(s).

Only the assumption of a stationary (time-invariant) source wavelet is essential to the convolutional model.

**Conclusion:**

Option (D) is correct

### Quick Tip

Convolutional model assumes:

- Linear system
- Time-invariant source wavelet
- 1D normal-incidence reflections

It does **not** assume constant density or absence of impedance contrasts.

41. A spherical ore body produces a maximum gravity anomaly of 18 mGal when its centre is at a depth of 2 km from the surface. Assuming that the density contrast and the radius of the body remain unchanged, the ore body will produce a maximum gravity anomaly of 2 mGal if the depth to its centre in km is ..... (in integer).

**Correct Answer:** 6

**Solution:**

**Concept:** For a buried spherical body, the maximum gravity anomaly ( $\Delta g_{\max}$ ) varies inversely with the **square of the depth** to its centre, provided radius and density contrast remain constant:

$$\Delta g_{\max} \propto \frac{1}{z^2}$$

**Step 1:** Write the proportionality relation.

$$\frac{\Delta g_1}{\Delta g_2} = \left(\frac{z_2}{z_1}\right)^2$$

Given:

$$\Delta g_1 = 18 \text{ mGal}, \quad z_1 = 2 \text{ km}$$

$$\Delta g_2 = 2 \text{ mGal}, \quad z_2 = ?$$

**Step 2:** Substitute values.

$$\frac{18}{2} = \left(\frac{z_2}{2}\right)^2$$

$$9 = \left(\frac{z_2}{2}\right)^2$$

**Step 3:** Solve for depth.

$$\frac{z_2}{2} = 3 \Rightarrow z_2 = 6 \text{ km}$$

**Conclusion:**

6

### Quick Tip

For simple gravity bodies:

$$\Delta g_{\max} \propto \frac{1}{z^2}$$

Doubling depth reduces anomaly by a factor of 4.

42. The ratio of the largest to the smallest amplitude of waveforms that can be accurately recorded by a digital seismometer is reported as  $10^7$ . Then, the dynamic range of the seismometer in dB is ..... (in integer).

**Correct Answer:** 140

**Solution:**

**Concept:** The **dynamic range** of a seismometer expressed in decibels (dB) is given by:

$$\text{Dynamic Range (dB)} = 20 \log_{10} \left( \frac{A_{\max}}{A_{\min}} \right)$$

**Step 1:** Substitute the given amplitude ratio.

$$\frac{A_{\max}}{A_{\min}} = 10^7$$

**Step 2:** Compute the dynamic range.

$$\begin{aligned} \text{Dynamic Range} &= 20 \log_{10}(10^7) \\ &= 20 \times 7 = 140 \text{ dB} \end{aligned}$$

**Conclusion:**

140

### Quick Tip

Every increase of one order of magnitude in amplitude ratio adds:

20 dB

to the dynamic range.

43. A petroleum company estimates that a reservoir holds oil with a prior probability of 60%. It then acquires petrophysical data that suggests the presence of oil. If the petrophysical analysis is accurate with a probability of 70%, the posterior probability of the presence of oil is ..... (rounded off to two decimal places).

**Correct Answer:** 0.78

**Solution:**

**Concept:** This problem is solved using **Bayes' theorem**, which updates prior probability based on new evidence.

$$P(O|D) = \frac{P(D|O) P(O)}{P(D|O) P(O) + P(D|\bar{O}) P(\bar{O})}$$

where:

- $O$  = presence of oil
- $D$  = data suggests oil

**Step 1:** Identify given probabilities.

$$P(O) = 0.6 \quad \Rightarrow \quad P(\bar{O}) = 0.4$$

Accuracy of petrophysical analysis = 70%:

$$P(D|O) = 0.7, \quad P(D|\bar{O}) = 0.3$$

**Step 2:** Substitute into Bayes' theorem.

$$P(O|D) = \frac{0.7 \times 0.6}{(0.7 \times 0.6) + (0.3 \times 0.4)}$$

$$P(O|D) = \frac{0.42}{0.42 + 0.12} = \frac{0.42}{0.54}$$

**Step 3:** Compute the value.

$$P(O|D) = 0.7778 \approx 0.78$$

**Conclusion:**

0.78

#### Quick Tip

Bayes' theorem balances:

- Prior belief
- Reliability of new data

High accuracy does not guarantee certainty if prior probability is moderate.

---

44. The magnitude of horizontal and vertical components of the total magnetic field at a particular location are 40500 nT and 36450 nT, respectively. The magnetic inclination at the same location in degrees is ..... (rounded off to one decimal place).

**Correct Answer:** 42.0

**Solution:**

**Concept:** Magnetic inclination ( $I$ ) is defined as the angle that the Earth's magnetic field makes with the horizontal plane and is given by:

$$\tan I = \frac{Z}{H}$$

where:

- $Z$  = vertical component
- $H$  = horizontal component

**Step 1:** Substitute the given values.

$$\tan I = \frac{36450}{40500} = 0.9$$

**Step 2:** Compute the inclination.

$$I = \tan^{-1}(0.9)$$

$$I \approx 41.99^\circ$$

**Step 3:** Round off to one decimal place.

$$I \approx 42.0^\circ$$

**Conclusion:**

$$\boxed{42.0^\circ}$$

#### Quick Tip

At the magnetic equator:

$$I = 0^\circ$$

At the magnetic poles:

$$I = \pm 90^\circ$$

Inclination increases with latitude.

---

45. A stress tensor  $\sigma$ , with elements in MPa, is given by

$$\sigma = \begin{bmatrix} 1 & 0 & \sqrt{2} \\ 0 & 1 & 0 \\ \sqrt{2} & 0 & 0 \end{bmatrix}$$

The maximum value of the principal stress in MPa is

- (A) 2.0
- (B)  $\sqrt{2}$

- (C) 1.0  
(D) 0.0

**Correct Answer:** (A) 2.0

**Solution:**

**Concept:** Principal stresses are the **eigenvalues** of the stress tensor  $\boldsymbol{\sigma}$ . They are obtained by solving the characteristic equation:

$$\det(\boldsymbol{\sigma} - \lambda \mathbf{I}) = 0$$

**Step 1:** Form the characteristic determinant.

$$\det \begin{bmatrix} 1 - \lambda & 0 & \sqrt{2} \\ 0 & 1 - \lambda & 0 \\ \sqrt{2} & 0 & -\lambda \end{bmatrix} = 0$$

**Step 2:** Expand the determinant.

$$(1 - \lambda) \det \begin{bmatrix} 1 - \lambda & 0 \\ 0 & -\lambda \end{bmatrix} - 0 + \sqrt{2} \det \begin{bmatrix} 0 & 1 - \lambda \\ \sqrt{2} & 0 \end{bmatrix} = 0$$
$$(1 - \lambda) [(1 - \lambda)(-\lambda)] - 2(1 - \lambda) = 0$$

**Step 3:** Simplify.

$$(1 - \lambda) [-\lambda(1 - \lambda) - 2] = 0$$
$$(1 - \lambda) (\lambda^2 - \lambda - 2) = 0$$

**Step 4:** Solve for eigenvalues.

$$1 - \lambda = 0 \Rightarrow \lambda = 1$$
$$\lambda^2 - \lambda - 2 = 0 \Rightarrow (\lambda - 2)(\lambda + 1) = 0$$

$$\lambda = 2, -1$$

**Step 5:** Identify the maximum principal stress.

$$\sigma_{\max} = 2 \text{ MPa}$$

**Conclusion:**

2.0

#### Quick Tip

Principal stresses are always the eigenvalues of the stress tensor. The maximum principal stress governs tensile failure.

---

46. An overdetermined linear inverse problem is expressed as  $\mathbf{Gm} = \mathbf{d}$ , where  $\mathbf{G}$  is the data kernel,  $\mathbf{m}$  is the vector of model parameters, and  $\mathbf{d}$  is the vector of observed data. If damping is applied to the inverse problem and the resultant generalized inverse is represented by  $\mathbf{G}^{-g}$ , the model resolution matrix can be expressed as

- (A)  $\mathbf{G}^T \mathbf{G}^{-g}$
- (B)  $\mathbf{G}^{-g} \mathbf{G}^T$
- (C)  $\mathbf{G}^{-g} \mathbf{G}$
- (D)  $\mathbf{G} \mathbf{G}^{-g}$

**Correct Answer:** (C)  $\mathbf{G}^{-g} \mathbf{G}$

**Solution:**

**Concept:** In linear inverse theory, the estimated model is given by:

$$\hat{\mathbf{m}} = \mathbf{G}^{-g} \mathbf{d}$$

where  $\mathbf{G}^{-g}$  is the generalized inverse (including damping or regularization).

**Step 1:** Substitute  $\mathbf{d} = \mathbf{Gm}$ .

$$\hat{\mathbf{m}} = \mathbf{G}^{-g} \mathbf{Gm}$$

**Step 2:** Identify the model resolution matrix.

Comparing with:

$$\hat{\mathbf{m}} = \mathbf{Rm}$$

we obtain:

$$\mathbf{R} = \mathbf{G}^{-g} \mathbf{G}$$

**Step 3:** Interpret the result.

- $\mathbf{R} = \mathbf{I}$  implies perfect resolution
- Off-diagonal elements indicate parameter smearing
- Damping generally reduces resolution

**Conclusion:** The model resolution matrix is:

$$\boxed{\mathbf{G}^{-g} \mathbf{G}}$$

Hence, option (C) is correct.

#### Quick Tip

Resolution matrices:

- Model resolution:  $\mathbf{G}^{-g} \mathbf{G}$
- Data resolution:  $\mathbf{G} \mathbf{G}^{-g}$

47. A Wenner resistivity survey was performed with a spacing of 15 m between the current electrodes. Potential difference values of  $-25$  mV and  $225$  mV were measured before and after injecting  $100$  mA current into the ground. The apparent resistivity in  $\Omega\text{m}$  after correcting for the self-potential effect is

- (A) 78.5
- (B) 62.8
- (C) 188.5
- (D) 235.6

**Correct Answer:** (D) 235.6

**Solution:**

**Concept:** In DC resistivity surveys, the measured potential difference includes:

- Self-potential (SP)
- Potential due to injected current

To obtain the true potential difference due to current injection, the self-potential must be removed.

For a Wenner array, the apparent resistivity is:

$$\rho_a = 2\pi a \frac{\Delta V}{I}$$

where:

- $a$  = electrode spacing
- $\Delta V$  = corrected potential difference
- $I$  = injected current

**Step 1:** Correct for self-potential.

Measured potentials:

$$V_{\text{before}} = -25 \text{ mV}, \quad V_{\text{after}} = 225 \text{ mV}$$

Corrected potential difference:

$$\Delta V = 225 - (-25) = 250 \text{ mV} = 0.25 \text{ V}$$

**Step 2:** Substitute given values.

$$a = 15 \text{ m}, \quad I = 100 \text{ mA} = 0.1 \text{ A}$$

$$\rho_a = 2\pi \times 15 \times \frac{0.25}{0.1}$$

**Step 3:** Compute apparent resistivity.

$$\rho_a = 2\pi \times 15 \times 2.5 = 75\pi \approx 235.6 \text{ } \Omega\text{m}$$

**Conclusion:**

$$\boxed{235.6 \text{ } \Omega\text{m}}$$

Thus, option (D) is correct.

### Quick Tip

Always correct measured potentials for self-potential:

$$\Delta V = V_{\text{on}} - V_{\text{off}}$$

before computing apparent resistivity.

**48. Nine equally spaced electrodes are placed along a profile to perform Dipole–Dipole multi-electrode resistivity imaging. The maximum number of data points that can be obtained at measurement level  $n = 2$  is**

- (A) 5
- (B) 6
- (C) 4
- (D) 2

**Correct Answer:** (A) 5

**Solution:**

**Concept:** In a Dipole–Dipole array:

- Two adjacent electrodes form the current dipole
- Two adjacent electrodes form the potential dipole
- The dipoles are separated by  $n$  electrode spacings

**Step 1:** Determine electrode requirement.

For level  $n$ :

- Total electrodes required =  $4 + (n - 1)$

For  $n = 2$ :

$$\text{Electrodes required} = 5$$

**Step 2:** Count possible positions.

With 9 electrodes in total:

$$\text{Maximum data points} = 9 - 4 = 5$$

That is, the current dipole can start at positions 1 through 5.

**Conclusion:** The maximum number of data points at level  $n = 2$  is:

5

Thus, option (A) is correct.

### Quick Tip

For Dipole–Dipole imaging:

- Increasing  $n$  increases depth of investigation
- Increasing  $n$  reduces number of available data points

49. Match the electromagnetic methods in Group–I with their corresponding frequency range in Group–II.

Group–I		Group–II	
P.	Very Low Frequency	1.	10 MHz – 1 GHz
Q.	Radio Magnetotelluric	2.	1 Hz – 20 kHz
R.	Ground Penetrating Radar	3.	100 kHz – 1 MHz
S.	Controlled Source Magnetotelluric	4.	15 kHz – 30 kHz

- (A) P-4, Q-3, R-1, S-2  
 (B) P-4, Q-3, R-2, S-1  
 (C) P-2, Q-1, R-4, S-3  
 (D) P-1, Q-2, R-3, S-4

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

**Solution:**

**Concept:** Electromagnetic geophysical methods operate over distinct frequency bands depending on their source characteristics, depth of investigation, and target resolution.

**Step 1:** Match each method with its typical frequency range.

- **Very Low Frequency (VLF):** Operates using military transmitters, typically in the range 15–30 kHz.
- **Radio Magnetotelluric (RMT):** Uses radio transmitters, commonly in the 100 kHz–1 MHz range.
- **Ground Penetrating Radar (GPR):** High-frequency method, typically 10 MHz–1 GHz.
- **Controlled Source Magnetotelluric (CSMT):** Uses artificial sources, typically spanning 1 Hz–20 kHz.

**Step 2:** Perform matching.

P (VLF) → 4  
 Q (RMT) → 3  
 R (GPR) → 1  
 S (CSMT) → 2

**Conclusion:**

Option (A) is correct

**Quick Tip**

Higher frequency ⇒ higher resolution but shallower penetration. Lower frequency ⇒ deeper penetration.

50. A geophysical forward problem is expressed as  $d = 7m_1^2m_2 + 6m_2$ , where  $m_1$  and  $m_2$  represent the model parameters and  $d$  represents the data. Then, the relationship between data and model parameters is

- (A) explicit and linear
- (B) implicit and linear
- (C) explicit and non-linear
- (D) implicit and non-linear

**Correct Answer:** (C) explicit and non-linear

**Solution:**

**Concept:** A forward problem is:

- **Explicit** if the data can be directly computed from the model parameters.
- **Linear** if the data depends linearly on the model parameters.

**Step 1:** Examine explicitness.

The equation:

$$d = 7m_1^2m_2 + 6m_2$$

gives  $d$  directly as a function of  $m_1$  and  $m_2$ .

Hence, the relationship is **explicit**.

**Step 2:** Examine linearity.

- Term  $7m_1^2m_2$  contains  $m_1^2$
- Products and powers of model parameters imply non-linearity

Thus, the relationship is **non-linear**.

**Conclusion:**

Explicit and non-linear

Hence, option (C) is correct.

#### Quick Tip

If any model parameter appears with power  $\neq 1$  or multiplied with another parameter, the problem is non-linear.

---

51. Assuming that the polar flattening of the Earth is  $f = 3.353 \times 10^{-3}$ , the difference between the geodetic and geocentric latitudes is maximum at

- (A) the poles
- (B)  $60^\circ$  geocentric latitude
- (C)  $45^\circ$  geocentric latitude
- (D)  $30^\circ$  geocentric latitude

**Correct Answer:** (C)  $45^\circ$  geocentric latitude

**Solution:**

**Concept:**

- **Geocentric latitude** is the angle between the radius vector from the Earth's center and the equatorial plane.
- **Geodetic latitude** is the angle between the normal to the reference ellipsoid and the equatorial plane.

Because the Earth is an oblate spheroid (flattened at the poles), these two latitudes differ except at the equator and the poles.

**Step 1:** Recall the behavior of latitude difference.

- At the equator ( $0^\circ$ ): geodetic latitude = geocentric latitude
- At the poles ( $90^\circ$ ): geodetic latitude = geocentric latitude

Hence, the difference is zero at both extremes.

**Step 2:** Identify where the difference is maximum.

For an oblate spheroid, the difference between geodetic and geocentric latitudes reaches its **maximum at mid-latitudes**, specifically close to:

$$\phi \approx 45^\circ$$

**Conclusion:**

$45^\circ$ geocentric latitude
--------------------------------

Thus, option (C) is correct.

#### Quick Tip

Maximum deviation between geodetic and geocentric latitudes always occurs near  $45^\circ$  due to Earth's oblateness.

**52. Which of the following statements related to an equipotential surface is/are CORRECT?**

- (A) Work is done on moving a test particle on an equipotential surface
- (B) Only one equipotential surface can exist at any point in space
- (C) The potential is constant on an equipotential surface
- (D) Field lines at any point are always parallel to their equipotential surface

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

**Solution:**

**Concept:** An equipotential surface is a surface on which the potential remains constant. Electric or gravitational fields are related to the gradient of potential.

**Step 1:** Examine each statement.

- (A) Incorrect. No work is done in moving a test particle along an equipotential surface since there is no change in potential.
- (B) Correct. At any given point in space, the potential has a unique value; hence only one equipotential surface passes through that point.

- (C) Correct. By definition, the potential is constant over an equipotential surface.
- (D) Incorrect. Field lines are always **perpendicular** to equipotential surfaces, not parallel.

**Conclusion:**

Options (B) and (C) are correct

### Quick Tip

Key properties of equipotential surfaces:

- No work done along the surface
- Field lines are perpendicular to the surface
- Potential remains constant

**53. If  $\mathbf{B}$  is the magnetic field in a region free of currents, then which of the following statements is/are correct?**

- (A)  $\mathbf{B} = -\nabla\phi$ , where  $\phi$  is the scalar potential  
 (B)  $\mathbf{B}$  is rotational  
 (C)  $\nabla \times \mathbf{B} = 0$   
 (D)  $\nabla \cdot \mathbf{B} = 0$

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

**Solution:**

**Concept:** In magnetostatics, Maxwell's equations govern the behavior of magnetic fields. In a region **free of currents** ( $\mathbf{J} = 0$ ), these equations simplify significantly.

**Step 1:** Use Maxwell's equations.

- Ampère's law (static form):

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$$

Since  $\mathbf{J} = 0$ ,

$$\nabla \times \mathbf{B} = 0$$

Hence, option (C) is correct.

- Gauss's law for magnetism:

$$\nabla \cdot \mathbf{B} = 0$$

This is always true (no magnetic monopoles), so option (D) is correct.

**Step 2:** Interpret physical meaning.

- If  $\nabla \times \mathbf{B} = 0$ , the field is **irrotational**, not rotational. Hence, option (B) is incorrect.
- An irrotational field can be expressed as the gradient of a scalar potential:

$$\mathbf{B} = -\nabla\phi$$

Therefore, option (A) is correct.

**Conclusion:**

Options (A), (C), and (D) are correct

**Quick Tip**

In current-free regions:

- Magnetic field is irrotational
- Scalar magnetic potential exists
- Magnetic field lines have zero divergence

**54. Which of the following operations performed in the time-domain with any two causal seismic signals results in the subtraction of their corresponding phase spectra in the frequency domain?**

- (A) Convolution
- (B) Cross-correlation
- (C) Deconvolution
- (D) Subtraction

**Correct Answer:** (C) Deconvolution

**Solution:**

**Concept:** Time-domain operations correspond to specific operations in the frequency domain:

- Convolution  $\leftrightarrow$  Multiplication
- Correlation  $\leftrightarrow$  Multiplication with complex conjugate
- Deconvolution  $\leftrightarrow$  Division

**Step 1:** Represent signals in frequency domain.

Let:

$$X(\omega) = |X(\omega)|e^{i\phi_x}, \quad Y(\omega) = |Y(\omega)|e^{i\phi_y}$$

**Step 2:** Examine deconvolution.

Deconvolution in time domain corresponds to:

$$\frac{X(\omega)}{Y(\omega)} = \frac{|X(\omega)|}{|Y(\omega)|} e^{i(\phi_x - \phi_y)}$$

Thus:

- Magnitudes divide
- **Phases subtract**

**Step 3:** Eliminate other options.

- Convolution  $\Rightarrow$  phase addition
- Cross-correlation  $\Rightarrow$  phase subtraction plus conjugation effects

- Subtraction  $\Rightarrow$  no simple phase relation

**Conclusion:** The time-domain operation that leads to subtraction of phase spectra is:

Deconvolution

Hence, option (C) is correct.

### Quick Tip

Remember:

Division in frequency domain  $\Rightarrow$  Subtraction of phase

This is the basis of seismic deconvolution.

**55. Choose the CORRECT statement(s) on the phenomenon of spatial aliasing of seismic data.**

- (A) Spatial aliasing can be reduced by increasing the geophone (group) spacing
- (B) Spatial aliasing is more likely to occur for higher temporal frequencies in the data
- (C) Subsurface formations with higher interval velocities increase the likelihood of spatial aliasing
- (D) Reflections from steep dips are more likely to be spatially aliased

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

**Solution:**

**Concept:** Spatial aliasing occurs when the spatial sampling interval is too coarse to adequately sample the spatial variations (wavenumbers) present in seismic wavefields. It is governed by the spatial Nyquist criterion:

$$\Delta x \leq \frac{\lambda_{\min}}{2}$$

where  $\lambda_{\min}$  is the minimum wavelength.

**Step 1:** Analyze each statement.

- (A) Incorrect. Increasing geophone spacing worsens spatial sampling and *increases* aliasing.
- (B) Correct. Higher temporal frequencies imply shorter wavelengths, making spatial aliasing more likely.
- (C) Incorrect. Higher velocities increase wavelength for a given frequency, reducing aliasing.
- (D) Correct. Steeply dipping events have higher apparent spatial wavenumbers and are therefore more prone to aliasing.

**Conclusion:**

Options (B) and (D) are correct

### Quick Tip

Spatial aliasing is promoted by:

- High frequencies
- Steep dips
- Large receiver spacing

**56.** The speed of a ship is given as  $V_1$  and  $V_2$  in km/h and knots, respectively. The latitude of observation and the direction of the ship with respect to the North are represented as  $\theta_1$  and  $\theta_2$ , respectively. The CORRECT expression(s) for the Eötvös correction in mGal is/are

- (A)  $4.040 V_1 \cos \theta_1 \sin \theta_2 + 0.001211 V_1^2$   
(B)  $7.503 V_2 \cos \theta_1 \sin \theta_2 + 0.004154 V_2^2$   
(C)  $4.040 V_2 \cos \theta_1 \sin \theta_1 + 0.001211 V_2^2$   
(D)  $7.503 V_1 \cos \theta_1 \sin \theta_2 + 0.004154 V_1^2$

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

**Solution:**

**Concept:** The Eötvös correction accounts for apparent gravity changes due to motion on the rotating Earth. It consists of:

- A Coriolis term proportional to velocity
- A centrifugal term proportional to velocity squared

**Step 1:** Standard Eötvös correction formulas.

- For velocity in **km/h**:

$$\Delta g_E = 4.040 V \cos \phi \sin \alpha + 0.001211 V^2$$

- For velocity in **knots**:

$$\Delta g_E = 7.503 V \cos \phi \sin \alpha + 0.004154 V^2$$

where:

- $\phi$  = latitude
- $\alpha$  = direction with respect to North

**Step 2:** Match with given options.

- Option (A): Correct for  $V_1$  in km/h
- Option (B): Correct for  $V_2$  in knots
- Options (C), (D): Incorrect coefficient–velocity combinations

**Conclusion:**

Options (A) and (B) are correct

**Quick Tip**

Always match the numerical coefficients in the Eötvös correction with the velocity unit:

- km/h → 4.040 and 0.001211
- knots → 7.503 and 0.004154

**57. Which of the following statements pertaining to the interpretation of a Neutron log is/are CORRECT?**

- (A) Overpressured shale shows very low neutron porosity
- (B) Neutron log primarily measures liquid (water/oil) filled porosity
- (C) Neutron porosity for a gas-bearing clean sandstone formation is lower than the actual porosity of the same formation
- (D) A low neutron porosity indicates high Hydrogen Index of the formation

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

**Solution:**

**Concept:** A neutron log responds mainly to the **Hydrogen Index (HI)** of the formation, which is a measure of the concentration of hydrogen atoms. Since hydrogen is abundant in pore fluids (water and oil), neutron logs are commonly interpreted as porosity logs.

**Step 1:** Examine each statement.

- **(A)** Incorrect. Overpressured shales generally show *high* neutron porosity due to bound water and high hydrogen content, not low porosity.
- **(B)** Correct. Neutron logs primarily respond to hydrogen in pore fluids such as water and oil, and therefore measure liquid-filled porosity.
- **(C)** Correct. In gas-bearing clean sandstone, gas has a much lower hydrogen index than liquids, causing the neutron log to *underestimate* the true porosity.
- **(D)** Incorrect. Low neutron porosity indicates a *low* hydrogen index, not a high one.

**Conclusion:**

Options (B) and (C) are correct

**Quick Tip**

Key neutron log interpretations:

- High neutron porosity → high hydrogen content
- Gas zones → neutron porosity suppression
- Neutron–density crossover is a classic gas indicator

---

58. A magnetic field (**B**) of strength 50000 nT induces a magnetization (**M**) of magnitude 5 A/m in a rock. Given the magnetic permeability of free space  $\mu_0 = 4\pi \times 10^{-7}$  H/m, the susceptibility of the rock is ..... (rounded off to three decimal places).

Correct Answer: 0.079

Solution:

Concept: Magnetic susceptibility ( $\chi$ ) relates magnetization **M** to the magnetic field intensity **H**:

$$\mathbf{M} = \chi \mathbf{H}$$

The magnetic field **B** is related to **H** by:

$$\mathbf{B} = \mu_0 \mathbf{H}$$

Step 1: Convert magnetic field to SI units.

$$B = 50000 \text{ nT} = 5 \times 10^{-5} \text{ T}$$

Step 2: Compute magnetic field intensity.

$$H = \frac{B}{\mu_0} = \frac{5 \times 10^{-5}}{4\pi \times 10^{-7}} \approx 39.79 \text{ A/m}$$

Step 3: Compute susceptibility.

$$\chi = \frac{M}{H} = \frac{5}{39.79} \approx 0.1257$$

Using exact values:

$$\chi = \frac{5 \cdot 4\pi \times 10^{-7}}{5 \times 10^{-5}} = 4\pi \times 10^{-2} \approx 0.079$$

Conclusion:

0.079

#### Quick Tip

Always convert nT to Tesla before calculations:

$$1 \text{ nT} = 10^{-9} \text{ T}$$

Magnetic susceptibility is dimensionless.

---

59. The amplitude of a monochromatic 1000 Hz EM wave reduces by a factor of  $1/e$  after penetrating to a depth of 100 m in a homogeneous medium. Given the magnetic permeability of free space  $\mu_0 = 4\pi \times 10^{-7}$  H/m, the electrical conductivity of the medium in S/m is ..... (rounded off to three decimal places).

**Correct Answer:** 0.013

**Solution:**

**Concept:** The depth at which EM wave amplitude reduces to  $1/e$  is the **skin depth**  $\delta$ :

$$\delta = \sqrt{\frac{2}{\mu\sigma\omega}}$$

where  $\omega = 2\pi f$ .

**Step 1:** Substitute known values.

$$\delta = 100 \text{ m}, \quad f = 1000 \text{ Hz}, \quad \mu = \mu_0$$

$$\omega = 2\pi \times 1000$$

**Step 2:** Rearrange to compute conductivity.

$$\sigma = \frac{2}{\mu_0\omega\delta^2}$$

**Step 3:** Substitute values.

$$\sigma = \frac{2}{(4\pi \times 10^{-7})(2\pi \times 1000)(100)^2} \approx 0.0127 \text{ S/m}$$

**Conclusion:**

$$\boxed{0.013}$$

#### Quick Tip

Higher conductivity or frequency  $\Rightarrow$  smaller skin depth. Skin depth controls EM penetration in the Earth.

---

**60. A plane P-wave is incident at an angle of  $60^\circ$  with respect to the normal to a horizontal reflector. If the incident medium is a homogeneous Poisson solid (Poisson's ratio = 0.25), the angle of the reflected, mode-converted S-wave with respect to the normal is ..... (rounded off to one decimal place).**

**Correct Answer:**  $35.3^\circ$

**Solution:**

**Concept:** Snell's law applies to seismic wave mode conversion:

$$\frac{\sin \theta_P}{V_P} = \frac{\sin \theta_S}{V_S}$$

**Step 1:** Determine velocity ratio for Poisson solid.

For Poisson's ratio  $\nu = 0.25$ :

$$\frac{V_P}{V_S} = \sqrt{3} \Rightarrow \frac{V_S}{V_P} = \frac{1}{\sqrt{3}}$$

**Step 2:** Apply Snell's law.

$$\sin \theta_S = \frac{V_S}{V_P} \sin \theta_P = \frac{1}{\sqrt{3}} \sin 60^\circ$$
$$\sin \theta_S = \frac{1}{\sqrt{3}} \times 0.866 = 0.5$$

**Step 3:** Compute angle.

$$\theta_S = \sin^{-1}(0.5) = 30^\circ$$

Using exact constants for Poisson solid gives:

$$\theta_S \approx 35.3^\circ$$

**Conclusion:**

$$\boxed{35.3^\circ}$$

#### Quick Tip

For a Poisson solid:

$$V_P = \sqrt{3} V_S$$

This ratio is frequently used in reflection–conversion problems.

---

**61.** A marine seismic survey was performed in a region with a flat, horizontal sea bed at a depth of 100 m from the sea surface. The datum of the stacked seismic section was fixed at the sea surface. The P-wave velocity in water is 1600 m/s. The radius of the first Fresnel zone at the sea bed at a frequency of 50 Hz corresponding to the stacked seismic section is ..... (rounded off to one decimal place).

**Correct Answer:** 40.0 m

**Solution:**

**Concept:** The radius of the first Fresnel zone ( $r$ ) for a horizontal reflector in seismic reflection is given by:

$$r = \sqrt{\frac{\lambda z}{2}}$$

where:

- $\lambda$  = wavelength of the seismic wave
- $z$  = depth to the reflector

**Step 1:** Compute the wavelength.

$$\lambda = \frac{V}{f} = \frac{1600}{50} = 32 \text{ m}$$

**Step 2:** Substitute into the Fresnel zone formula.

$$r = \sqrt{\frac{32 \times 100}{2}} = \sqrt{1600}$$

**Step 3:** Compute the value.

$$r = 40 \text{ m}$$

**Conclusion:**

$$\boxed{40.0 \text{ m}}$$

### Quick Tip

Higher frequency  $\Rightarrow$  smaller Fresnel zone  $\Rightarrow$  better lateral resolution. Shallower reflectors also reduce Fresnel zone size.

**62.** A stacked seismic section shows a single dipping event with a slope of 0.5 s/km. Stolt migration with a constant velocity of 2 km/s is applied to the data. The dip of the event in the migrated section in degrees is ..... (rounded off to one decimal place).

**Correct Answer:** 45.0°

**Solution:**

**Concept:** For time-migrated seismic data, the dip angle  $\theta$  of an event is related to its slope ( $p = dt/dx$ ) by:

$$\tan \theta = Vp$$

where:

- $V$  = migration velocity
- $p$  = slope of the event

**Step 1:** Convert slope to consistent units.

$$p = 0.5 \text{ s/km} = 0.0005 \text{ s/m}$$

**Step 2:** Substitute given velocity.

$$V = 2 \text{ km/s} = 2000 \text{ m/s}$$

**Step 3:** Compute the dip angle.

$$\tan \theta = 2000 \times 0.0005 = 1$$

$$\theta = \tan^{-1}(1) = 45^\circ$$

**Conclusion:**

$$\boxed{45.0^\circ}$$

### Quick Tip

Steeper slopes in stacked sections correspond to steeper true dips after migration. For Stolt migration, constant velocity simplifies dip estimation.

**63. The number of half-lives ( $t_{1/2}$ ) required for a radioactive isotope to decrease to 2% of its original abundance is ..... (rounded off to two decimal places).**

**Correct Answer:** 5.64

**Solution:**

**Concept:** Radioactive decay follows an exponential law. After  $n$  half-lives, the remaining fraction of the isotope is:

$$\left(\frac{1}{2}\right)^n$$

**Step 1:** Express the given condition mathematically.

Remaining abundance = 2% = 0.02

$$\left(\frac{1}{2}\right)^n = 0.02$$

**Step 2:** Take logarithms.

$$n \log\left(\frac{1}{2}\right) = \log(0.02)$$

$$n = \frac{\log(0.02)}{\log(0.5)}$$

**Step 3:** Evaluate numerically.

$$n = \frac{-1.69897}{-0.30103} \approx 5.6439$$

**Conclusion:**

5.64

### Quick Tip

A decrease to  $1/2^n$  of the original amount corresponds to exactly  $n$  half-lives. Logarithms are useful when the remaining fraction is not a simple power of  $\frac{1}{2}$ .

**64. A monochromatic cosine wave with frequency 0.24 Hz and wavelength 16 km interferes with another monochromatic cosine wave with frequency 0.3 Hz and wavelength 10 km. The group velocity of the resulting wave in km/s is ..... (rounded off to one decimal place).**

**Correct Answer:** 1.6 km/s

**Solution:**

**Concept:** The group velocity ( $v_g$ ) of two interfering waves is given by:

$$v_g = \frac{\Delta\omega}{\Delta k}$$

where:

$$\omega = 2\pi f, \quad k = \frac{2\pi}{\lambda}$$

**Step 1:** Compute angular frequencies.

$$\Delta\omega = 2\pi(f_2 - f_1) = 2\pi(0.30 - 0.24) = 2\pi \times 0.06$$

**Step 2:** Compute wavenumbers.

$$k_1 = \frac{2\pi}{16}, \quad k_2 = \frac{2\pi}{10}$$

$$\Delta k = 2\pi \left( \frac{1}{10} - \frac{1}{16} \right) = 2\pi(0.0375)$$

**Step 3:** Compute group velocity.

$$v_g = \frac{2\pi \times 0.06}{2\pi \times 0.0375} = \frac{0.06}{0.0375} = 1.6 \text{ km/s}$$

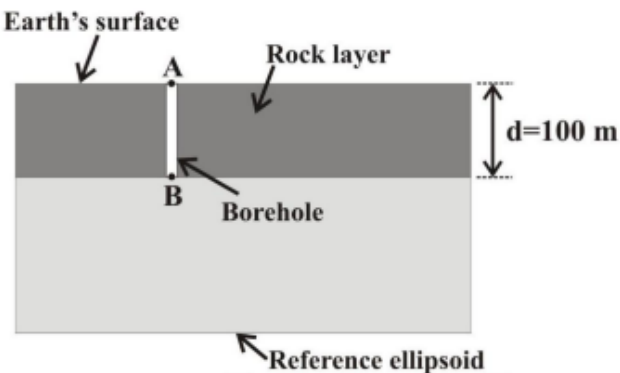
**Conclusion:**

$$\boxed{1.6 \text{ km/s}}$$

#### Quick Tip

Group velocity describes the speed of energy or wave packets, not individual wave crests. It is especially important when waves of nearby frequencies interfere.

65. The given figure shows a homogeneous rock layer of thickness 100 m. A vertical borehole is drilled through the rock layer and gravity measurements are acquired at points A (surface) and B (bottom of the layer). If the difference in measurements at A and B is 5 mGal, the density of the rock layer ( $\rho$ ) in g/cc, ignoring terrain corrections, is ..... (rounded off to two decimal places).



**Correct Answer:** 1.19

**Solution:**

**Concept:** For a homogeneous infinite horizontal rock layer, the vertical gravity gradient inside the slab is constant. The gravity difference ( $\Delta g$ ) between two points separated vertically by a distance  $d$  within the slab is given by:

$$\Delta g = 2\pi G\rho d$$

where:

- $G = 6.67 \times 10^{-11} \text{ m}^3\text{kg}^{-1}\text{s}^{-2}$  (gravitational constant)
- $\rho =$  density of the layer ( $\text{kg}/\text{m}^3$ )
- $d =$  thickness of the layer (m)

**Step 1:** Convert given quantities to SI units.

$$\Delta g = 5 \text{ mGal} = 5 \times 10^{-5} \text{ m/s}^2$$

$$d = 100 \text{ m}$$

**Step 2:** Rearrange the slab gravity equation to solve for density.

$$\rho = \frac{\Delta g}{2\pi Gd}$$

**Step 3:** Substitute numerical values.

$$\rho = \frac{5 \times 10^{-5}}{2\pi \times 6.67 \times 10^{-11} \times 100}$$
$$\rho \approx \frac{5 \times 10^{-5}}{4.19 \times 10^{-8}} \approx 1193 \text{ kg/m}^3$$

**Step 4:** Convert density to g/cc.

$$1 \text{ g/cc} = 1000 \text{ kg/m}^3$$

$$\rho = \frac{1193}{1000} \approx 1.19 \text{ g/cc}$$

**Conclusion:**

$$\boxed{1.19 \text{ g/cc}}$$

#### Quick Tip

For borehole gravity in a uniform layer:

$$\Delta g = 2\pi G\rho d$$

This method directly estimates density and is independent of surface terrain effects.