GATE 2024 Geology & Geophysics - Geophysics (GG2) Solutions

General Aptitude (GA) Q.1 – Q.5 Carry ONE mark Each

Ques.1 If '→' denotes increasing order of intensity, then the meaning of the words [simmer → seethe → smolder] is analogous to [break → raze → _____]. Which one of the given options is appropriate to fill the blank?
(A) obfuscate
(B) obliterate
(C) fracture
(D) fissure

Solution. (B) obliterate , To determine which word appropriately fills the blank in the analogy, we need to understand the progression of intensity in both series of words.

- "Simmer," "seethe," and "smolder" all describe states of increasing intensity of heat or anger.
- "Break" and "raze" similarly describe states of increasing intensity of destruction.

Given this pattern, we need a word that represents a higher intensity of destruction than "raze."

Let's evaluate the options:

(A) Obfuscate - This means to confuse or make unclear. It does not fit the context of destruction.

(B) Obliterate - This means to destroy completely, which is a higher intensity of destruction than "raze."

(C) Fracture - This means to break or crack. It is similar in intensity to "break," not higher.

(D) Fissure - This means a narrow opening or crack. It is also not higher in intensity than "raze."

Therefore, the appropriate word to fill the blank is:

(B) obliterate

Ques.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

Solution. To find the value of x in the sequence 3,7,15,x,63,127,255, we should identify the pattern in the sequence.

First, let's observe the given numbers and try to find a pattern.

Notice that each term appears to be one less than a power of 2:

- $3 = 2^2-1$
- $7=2^3-1$
- $15=2^4-1$
- x
- $63=2^6-1$
- $127=2^7-1$

- $255=2^8-1$

Based on this pattern, x should be 2^5-1:

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

So, the possible value of x in the sequence is 31.

The correct answer is: (D) 31

Ques.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

Solution. (C) 50 , To determine how many times the second-hand and the minute-hand of a clock will cross each other between 12:05:00 and 12:55:00, we need to understand their relative speeds and crossing pattern.

Calculation Steps:

1. Relative Speed and Crossing Pattern:
    - The second-hand completes one full rotation (360 degrees) every 60 seconds.
    - The minute-hand completes one full rotation (360 degrees) every 60 minutes.
    - The relative speed between the second-hand and the minute-hand is $360 \div 60 = 6$ degrees per minute.
2. Crossing Points Calculation:

    - From 12:05:00 to 12:55:00, both hands start at 12 and move towards each other.
3. Formula for Number of Crossings:
    - The number of times they cross each other is given by the formula $|6M - 0.5S|$, where:
        - M is the number of minutes past the hour,
        - S is the number of seconds past the minute.
4. Specific Analysis for the Time Interval (12:05:00 to 12:55:00):
    - For each minute, they cross once because the relative angle covered by the second-hand relative to the minute-hand (6 degrees per minute) ensures one crossing per minute.
5. Total Calculation:
    - From 12:05:00 to 12:55:00, there are 50 minutes (from 5 minutes past 12 to 55 minutes past 12).
    - Therefore, they cross 505050 times during this interval.

Conclusion:

The second-hand and the minute-hand of the clock will cross each other 50\boxed{50}50 times between 12:05:00 and 12:55:00 hours.

Q.6 – Q.10 Carry TWO marks Each

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

Solution. (D) (i) holds (ii) waits (iii) culminate (iv) pivots , Let's fill in the blanks one by one:

1. From the ancient Athenian arena to the modern Olympic stadiums, athletics ___ the potential for a spectacle.
    - The correct form should be singular, so "holds" is appropriate.
2. The crowd ___ with bated breath as the Olympian artist twists his body, stretching the javelin behind him.
    - The crowd (singular collective noun) "waits" with bated breath.
3. Twelve strides in, he begins to cross-step. Six cross-steps ___ in an abrupt stop on his left foot.
    - "Culminate" is the correct form because it should be plural to match "steps".
4. As his body ___ like a door turning on a hinge, the javelin is launched skyward at a precise angle.
    - The subject "body" is singular, so "pivots" is the appropriate form.

Thus, the best match for all the blanks is:

(D) (i) holds (ii) waits (iii) culminate (iv) pivots

PART A: COMPULSORY SECTION FOR ALL CANDIDATES Q.11– Q .17 Carry ONE mark Each

Ques.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

Solution.(B) Outer core ,The Earth's magnetic field is produced by electric currents that are created by the convective movements of the molten iron and nickel in the outer core.

Ques.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

Solution.(D) Caliper , By measuring the borehole's diameter, a caliper log can be used to detect any variations in the hole's size that might point to the existence of cavities or cracks.

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

(A) Granite

(B) Gabbro

(C) Dunite

(D) Basalt

Solution.(C) Dunite,Olivine makes up practically the entire composition of dunite, a form of ultramafic rock. Ultramafic rocks are rich in minerals like pyroxene and olivine and have very little silica in them.

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

(A) Baula

(B) Hutti

(C) Dariba

(D) Jaduguda

Solution. (B) Hutti , The Hutti Gold Mines are the main source of gold production in India,Situated in the state of Karnataka, Hutti Gold Mines is one of the largest gold mines in India.

Ques.17 A cylindrical sample of granite (diameter = 54.7 mm; length = 137 mm) shows a linear relationship between axial stress and axial strain 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 _____ (in integer).

Solution. We can use the following formula to determine the granite sample's Young's modulus, or E E:

$E=\sigma\ \epsilon$ E=

where

Where is the strain, σ is the stress.

As stated:

200 MPa is the uniaxial compressive strength (σσ).

Peak stress axial strain (ϵ€) = 0.005

To begin, translate the stress into Pascal (Pa):

σ = 200 MPa = 200 × 1 0 6 Pa

σ = 200 MPa = 200×10^6 Pa

Compute the Young's modulus now.

E E:

E = 200 × 1 0 6 Pa 0.005 E = 0.005 200 × 10 6 Pa

E= 0.005 200,000,000 A = 200, 000, 000

E = 40, 000, 000, 000 Pa

E is equal to 40,000,000,000 Pa.

Pa to GPa conversion: E = 40, 000, 000, 000 1 0 9 GPa

E is equal to 10^9

40,000,000 GPa.

E = 40 GPa

E equals 40 GPa

As a result, the granite sample's Young’s modulus is 40gpa

Ques.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

Solution.(A) P-3, Q-4, R-2, S-1 , The following represents the accurate pairing of Group-I geophysical procedures with Group-II's corresponding physical properties:

(Q) Gravity - 4 (Density), (R) Magnetotelluric - 2 (Electrical conductivity), (S) Induced Polarization - 1 (Chargeability), and (A) P-3 (Magnetic - Susceptibility).

Thus, the response is A

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

(A) Holocene

(B) Pleistocene

(C) Pliocene

(D) Miocene

Solution.(A) Holocene ,(B) Pleistocene, The most recent geological epoch, the Quaternary epoch, runs from roughly 2.6 million years ago to the present. Significant climate shifts, such as several ice ages and interglacial periods, are its defining features.

Among the choices offered are:

The Holocene, which began roughly 11,700 years ago and continues to the present, is the current geological epoch and is a part of the Quaternary Period.

The Pleistocene, which lasted from roughly 2.6 million to 11,700 years ago and came before the Holocene, is another period of the Quaternary Period.

Thus, the appropriate response is:

Holocene (A) and Pleistocene (B)

Thus, the response is A and B.

Ques.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

Solution.(A) Olivine , The typical formula for olivine is (Mg,Fe)2SiO4, which results in an O:Si ratio of 4:1.

Quartz: The O:Si ratio of quartz is 2:1 due to its formula, SiO2.

Diopside: Diopside has an O:Si ratio of 3:1 and the formula CaMgSi2O6.

Albite: Albite has an O:Si ratio of 8:3 with the formula $NaAlSi_3O_8$.

In summary

As a result, (A) Olivine is the mineral with an O:Si ratio of 4:1.

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

(A) Antiform

(B) Horst

(C) Syncline

(D) Synform

Solution.(A) Antiform, (C) Syncline ,(D) Synform, Among the choices offered are:

(A) Antiform: An antiform is a particular kind of fold in which the rock layers form an extended, convex arch upward.(C) Syncline: A syncline is a fold that resembles a trough when the rock layers arch downward.

Thus, these are the appropriate responses:

(A) Syncline Option (C) Antiform (B) Horst is an elevated block of the Earth's crust surrounded by typical faults rather than a fold structure.

Choice (D) In structural geology, fold structures are not usually referred to as "synforms."

Therefore, A and C is the right response.

Ques.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 mW/m2 and 22

mW/m2 , respectively, the radiogenic heat production in the given crustal layer in W/m3 is _____ (in integer).

Solution. The following formula can be used to compute the radiogenic heat production (A):

(Qs - Qr) / d = A

Changing the specified values:

A = 32 mW/m² / 16,000 m = 0.000002 mW/m³ = (54 mW/m² - 22 mW/m²) / 16,000 m

We multiply by 10^6 to translate to μW/m³:

A = 10^6 * 0.000002 mW/m³ = 2 μW/m³

Consequently, 2 μW/m³ is the radiogenic heat generation in the specified crustal layer.

Ques.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 m2 /day is _____ (rounded off to one decimal place).

Solution. Calculating transmissivity (T) involves multiplying hydraulic conductivity (K) by saturated thickness (b):

T is equal to K * b.

But we must make sure that the units are constant. The hydraulic conductivity can now be converted from cm/s to m/day:

Since there are 86400 seconds in a day, 1 cm/s equals 86400 cm/day.

10^-2 * 86400 cm/day = 864 cm/day is equal to 10^-2 cm/s.

By dividing by 100, you may convert cm/day to m/day (864 cm/day = 8.64 m/day).

We can now determine transmissivity:

* 10 m * 8.64 m/day = 86.4 m²/day

The aquifer's transmissivity, rounded to the next decimal place, is 86.4 m³/day.

Ques.26 A current of 2 A passes through a cylindrical rod with uniform cross-sectional area of 4 m2 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)

Solution. This difficulty can be resolved by applying Ohm's law and understanding the relationship between resistivity (ρ), electric field (E), and current density (J).

Find the density of current (J):

J is equal to I / A.

J = 0.5 A/m² = 2 A / 4 m²

Connect resistivity, electric field, and current density:

J = E / ρ Electric field (E) solution:

50 V/m = 0.5 A/m² * 100 Ω-m = E = J * ρ

As a result, the electric field's (E) magnitude is 50 V/m.

PART B2: FOR Geophysics CANDIDATES ONLY Q.27 – Q.44 Carry ONE mark Each

Ques.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

Solution.(B) mantle – outer core , The outer core-mantle boundary is explained by a considerable drop in P-wave (primary wave) velocity. This boundary is called the core-mantle boundary (CMB) or the Gutenberg discontinuity. P-waves see a discernible drop in velocity at this barrier because they move through the solid mantle more quickly than they do the liquid outer core. As a result, choice (B) is accurate.

Ques.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

Solution.(A) Common midpoint gather , A fold in a 2D seismic survey is the quantity of times that various seismic traces sample a given subsurface location (common midpoint). With the common midpoint gather, seismic sources are positioned at both endpoints of a straight line, and seismic receivers are positioned along its length. This configuration offers a higher fold of coverage for each midpoint by enabling data collecting from several perspectives. As a result, choice (A) is accurate.

Ques.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**

Solution. (A) 1 + Z **2 +** Z **4 ,** We may use the definition of the Z-transform directly given the sequence {1, 0, 1, 0, 1}:

X(z) = Σ * z^(-n) * x[n]

The Z-transform is X(z).

The sequence is denoted by x[n] ({1, 0, 1, 0, 1} in this case).

The sequence index is denoted by n.

A complicated variable is z.

When we use the formula, we obtain:

To get X(z), take the product of 1 * z^0 + 0 * z^(-1) + 1 * z^(-2) + 0 * z^(-3) + 1 * z^(-4).

We can multiply by z^4 to represent it with positive powers of z:

X(z) equals z^2 + z^4 + 1.

Consequently, (A) 1 + z^2 + z^4 is the Z-transform of the sequence {1, 0, 1, 0, 1}.

Ques.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

Solution. (D) Ground roll, The ground roll usually shows the maximum apparent slowness in a terrestrial seismic reflection study conducted with vertical component geophones. When compared to other seismic waves captured in vertical geophone data, ground roll is a form of surface wave that moves along the ground surface and is distinguished by a comparatively low frequency and high apparent velocity. As a result, choice (D) is accurate.

Ques.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 ε1 and ε2, respectively, the reflection coefficient at normal incidence is

(A) $\sqrt{\varepsilon 1} - \sqrt{\varepsilon 2}\ \sqrt{\varepsilon 1} + \sqrt{\varepsilon 2}$

(B) $\sqrt{\varepsilon 1} + \sqrt{\varepsilon 2}\ \sqrt{\varepsilon 1} - \sqrt{\varepsilon 2}$

(C) $\sqrt{\varepsilon 1}\ \sqrt{\varepsilon 1} + \sqrt{\varepsilon 2}$

(D) $\sqrt{\varepsilon 2}\ \sqrt{\varepsilon 1} + \sqrt{\varepsilon 2}$

Solution.(A) $\sqrt{\varepsilon 1} - \sqrt{\varepsilon 2}\ \sqrt{\varepsilon 1} + \sqrt{\varepsilon 2}$, For normal incidence, the following formula yields the reflection coefficient (R) at the interface between two dielectric mediums with dielectric constants ε1 and ε2:

Z2 - Z1 / Z2 + Z1 equals R.

Where:

The intrinsic impedances of the two media are denoted by Z1 and Z2.

The relationship between the dielectric constant (ε) and the intrinsic impedance (Z) for a non-magnetic medium is $Z = \sqrt{(\mu 0/\varepsilon)}$.

$Z \wedge 1/\sqrt{\varepsilon}$ can be simplified since μ0 (permeability of open space) is constant.

As a result, the reflection coefficient has the following expression:

R is equal to $(\sqrt{\varepsilon}1 - \sqrt{\varepsilon}2) / (\sqrt{\varepsilon}1 + \sqrt{\varepsilon}2)$

Therefore, (A) $\sqrt{\varepsilon}1 - \sqrt{\varepsilon}2 / \sqrt{\varepsilon}1 + \sqrt{\varepsilon}2$ is the right response.

Ques.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

Solution.(A) Self-Potential , The Self-Potential (SP) technique works well for detecting water seepage from dams. This technique measures the electrical potential changes produced by spontaneous electrochemical reactions linked to the flow of fluids through porous materials like rock or soil (such as water). The SP technique can identify electrical potential gradients caused by water seeping through a dam or embankment. As a result, choice (A) is accurate.

Ques.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

Solution.(C) strike-slip ,The image's focal mechanism is consistent with a strike-slip fault.

When two fault sides pass one another horizontally, the fault is said to be strike-slip. A strike-slip fault's focal mechanism is represented by a "T" form, with two compression and two dilatation quadrants. A strike-slip fault is compatible with the "T" form seen in the figure, which has two black quadrants representing compression and two white quadrants representing dilatation.For this reason, strike-slip (C) is the right response.

Ques.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

Solution. (B) Venus , Reason: At the moment, Venus lacks an internal magnetic field generated by an active dynamo. Venus lacks a magnetic field of this type, while Mercury, Earth, and Uranus all have magnetic fields produced by their internal dynamo systems.

Ques.36 The dimension of permeability is

(A) L

(B) L 2

(C) L 3

(D) L 2T -2

Solution.**(B) L 2** ,The ability of a substance, like rock or soil, to transfer fluids, like liquids or gasses, is measured as its permeability. The standard expression for its dimensional formula in the International System of Units (SI) is L 2 L 2, where L stands for length (measured in meters). This suggests that the SI unit of permeability is square meters (m^2).

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

(A) 0.92

(B) 1.46

(C) 1.76

(D) 2.62

Solution.**(B) 1.46 ,** The main energy level at which potassium (K) in subterranean rocks emits gamma rays is 1.46 MeV. In radiometric surveys, this distinctive energy peak is utilized to determine if potassium is present in geological formations.

Ques.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

Solution.**(C) Energy released from Earthquakes**,The annual heat budget of Earth takes into account a number of variables that affect its overall heat balance. Among the choices offered are:

In comparison to other components, geothermal flow from the Earth's interior makes a major contribution, but it is less in scale and rather steady.

Even though it varies, solar energy reflection and reradiation play a significant role in the Earth's heat budget.

Even while seismic energy is quite strong locally, it has little impact on the world heat budget.

Although tidal pressures cause rotational energy to be dissipated, this process—known as "rotational deceleration by tidal friction"—contributes very little to the overall heat budget.

Consequently, of the alternatives given, the one that adds the least amount of heat to the Earth's yearly heat budget is:

(D) Tidal friction causes a rotational deceleration

Ques.40 Identify the CORRECT assumption(s) supporting the convolutional model of zerooffset 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

Solution.(D) The source waveform is stationary, that is, the source waveform does not change as it travels in the subsurface, Assessing the Available Choices

(A) There is just one temporal frequency included in seismic data: This is untrue. There is a large variety of frequencies in seismic data.

(B) The material properties in the subsurface do not exhibit abrupt changes: This statement is erroneous as well. Sharp variations in material qualities, shown as spikes in the reflectivity series, can be accommodated by the convolutional model.

(C) The subsurface's density remains constant: The convolutional model does not technically require this assumption to function, even if it simplifies the model. The reflectivity series can be modified to account for variations in density.

(D) The source waveform is immobile, meaning it does not alter as it moves beneath the surface: A fundamental tenet of the convolutional model is this. It suggests that the source waveform is stationary, that is, the source waveform does not change as it travels in the subsurface

Ques.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).

Solution. Let us denote:

g1 represents the initial gravity anomaly (18 mGal).

z1 is the beginning depth (2 km).

g2 represents the final gravity anomaly (2 mGal).

z2 is the final depth (unknown).

Since the surplus mass and density contrast are constant, we may establish a proportion:

g1 / g2 = (z2^2) / (z1^2)

Substitute the given values:

18 / 2 = (z2^2) / (2^2)

Solving for z 2:

z2^2 = 18 * 4 / 2 = 36

Calculating the square root of both sides:

z2 = 6 km

Ques.42 The ratio of the largest to the smallest amplitude of waveforms that can be accurately recorded by a digital seismometer is reported as 107 . Then, the dynamic range of the seismometer in dB is _____(in integer).

Solution. The dynamic range of a digital seismometer is calculated in decibels (dB) by dividing the maximum to minimum amplitude of waveforms that may be correctly recorded. The formula for dynamic range in decibels is:

Dynamic Range (dB): 20 log 10 (R)

Dynamic Range (dB) = 20 log 10 (R).

The ratio of the largest to lowest amplitude, denoted by R, is given as 1:0:7:10:7.

Let us compute it:

Dynamic Range (dB) = 20 log 10 (1 0 7).

Dynamic Range (dB) = 20log 10 (10 7)

Dynamic Range (dB) = 20 x 7.

Dynamic Range (dB) = 20×7.

Dynamic Range (dB) equals 140.

Dynamic Range (dB) = 140.

The seismometer's dynamic range is 140 decibels (dB).

Ques.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).

Solution. The formula for magnetic inclination (I) is as follows:

Substituting the following values: tan(I) = Z/H.

tan(I) = 36450 nT/40500 nT.

Calculating the Inverse Tangent:

I = arctan(36450/40500).

Using a calculator, we obtain:

I ≈ 42.1 degrees.

Thus, the magnetic inclination at the same position is 42.1 degrees.

Q.45 – Q .65 Carry TWO marks Each

Ques.45 A stress tensor σ, with elements in MPa, is as given. The maximum value of the principal stress in MPa is σ = [1 0 √2 0 1 0 √2 0 0]

(A) 2.0

(B) √2

(C) 1.0

(D) 0.0

Solution.**(A) 2.0 ,** The major stresses are the stress tensor's eigenvalues.

Given the stress tensor:

σ = [1 0 √2]

[0 1 0]

[√2 0 0]

To obtain the eigenvalues, we solve the characteristic equation:

Det(σ - λI) = 0, where λ is the eigenvalue and I is the identity matrix.

det([1-λ 0 √2]

[0 1-λ 0]

Expanding the determinant yields: [√2 0 -λ]) = 0.

(1-λ)[(1-λ)(-λ) - 0] - 0 + √2[0 - √2(1-λ)] = 0

Simplifying:

(1-λ)(λ^2 - λ) - 2(1-λ) = 0 Factor out (1-λ).

(1-λ)(λ^2 - λ - 2) = 0

Solving the quadratic equation λ^2 - λ - 2 = 0 yields λ = 2 or λ = -1.

Thus, the maximum primary stress is 2 MPa.

Answer: (A) 2.0.

Q.46 An overdetermined linear inverse problem is expressed as $\mathbf{G}\boldsymbol{m} = \boldsymbol{d}$, where $\mathbf{G}$ is the data kernel, $\boldsymbol{m}$ is the vector of model parameters and $\boldsymbol{d}$ 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) $\mathbf{G}\mathbf{G}^{-g}$

Solution. **(C) $\mathbf{G}^{-g}\mathbf{G}$** Model Resolution Matrix

The model resolution matrix (R) connects the true model (m_true) with the estimated model (m_est):

m_est = R x m_true.

Given Information

Overdetermined system: Gm = d

Damped generalized inverse: G^-g.

Developing the Model Resolution Matrix

The estimated model is determined by applying the generalized inverse to the data:

m_est = G^-g * d, where d = Gm.

m_est=G^-g * G * m_true.

When comparing this to the definition of the model resolution matrix, we see that:

R = G^-g * G

The model resolution matrix can be represented as (C) G^-gG.

Ques.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. Control 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

Solution. **(A) P-4, Q-3, R-1, S-2 ,** To align electromagnetic methods with their respective frequency ranges:

P. Very Low Frequency (VLF) is 10 kHz - 30 kHz.

Q. Radio Magnetotelluric (RMT) corresponds to 1 Hz to 20 kHz.

R. Ground Penetrating Radar (GPR) covers the frequency range of 100 MHz to 1 GHz.

S. Controlled Source Magnetotelluric (CSMT) is equivalent to 10 kHz - 1 MHz.

Let's match them to the options presented.

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

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

(A) the poles

(B) 60º geocentric latitude

(C) 45º geocentric latitude

(D) 30º geocentric latitude

Solution.(C) 45º geocentric latitude, Geodetic and geocentric latitudes differ due to the Earth's polar flattening (*f*f). Geodetic latitude (ϕ) is the angle between the equatorial plane and the normal to the Earth's ellipsoidal surface, while geocentric latitude (ϕ') is the angle between the equatorial plane and the line linking a point on the ellipsoid to the center of the Earth.

The formula for comparing geodetic and geocentric latitudes is given by:

tan (ϕ') = (1 − f)

2 tan (ϕ)

tan(ϕ ′)=(1−f)

2 tan(ϕ)

Where f refers to the Earth's flattening.

The greatest discrepancy between geodetic and geocentric latitudes is at 4 ◦ and 45 ◦ geocentric latitude. Therefore, the right answer is C, 45º geocentric latitude.

Ques.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. If 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).

Solution.To determine the radius of the first Fresnel zone on the seabed, apply the formula that connects the Fresnel zone radius (r_F r F) to the depth ($\hbar$) and wavelength (λ):

$r_F = \lambda \cdot \hbar$ 2 r F= 2 λ·h

Given:

The depth of the sea bed ($\hbar$) is 100 m, and the P-wave velocity in water ($V\ w$ V w) is 1600 m/s.

The seismic survey frequency (f f) is 50 Hz.

To compute the wavelength λ, use the equation $\lambda = V\ w\ f$ λ= f V w.

:λ = 1600 m/s

50 Hz λ= 50 Hz

1600 m/s

λ = 32 m λ=32 m

Substitute $\hbar$ h and λ λ into the formula for $r\ \boldsymbol{R}$ r F.

$r\ F$ = 32 m $\cdot$ 100 m

2 r F= 2 32 m $\cdot$ 100 m

$r\ F$ = 1600 m 2 r F= 1600 m 2

$r\ F$ = 40 m

r F=40 m

Ques.63 The number of half-lives (t1/2) required for a radioactive isotope to decrease to 2 % of its original abundance is _____(rounded off to two decimal places).

Solution.After one half-life, the amount remaining is 50% (0.5) of the original.After two half-lives, the amount left is 25% (0.5 * 0.5 = 0.25) of the original.

After three half-lives, the amount left is 12.5% (0.5 * 0.5 * 0.5 = 0.125) of the original.

And so on.We can generalize this to:

quantity remained = original quantity * (0.5)^n, where n is the number of half-lives.We want to find n when the amount left is 2% (or 0.02) of the original:

0.02 = (0.5)^n

To solve for n, we can use the logarithm of both sides:

Log(0.02) = n * log(0.5).

n = log(0.02)/log(0.5).

Using a calculator, we obtain:

n ≈ 5.64

As a result, a radioactive isotope's abundance drops to 2% of its initial level after approximately 5.64 half-lives.

Ques.64 A monochromatic cosine wave with frequency of 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).

Solution. The group velocity (Vg) is defined as the rate at which the overall form of the wave's amplitude (the envelope) moves through space. The formula is as follows:

Vg equals Δω / Δk.

Δω represents the difference in angular frequencies.

Calculations: Δk represents the difference in wave numbers.

Calculate the angular frequency (ω):

$\omega_1 = 2\pi f_1 = 2\pi * 0.24 \text{ Hz} = 1.508 \text{ rad/s}$.

$\omega_2 = 2\pi f_2 = 2\pi * 0.3 \text{ Hz} \approx 1.885 \text{ rad/s}$.

$\Delta\omega = \omega_2 - \omega_1 \approx 0.377 \text{ rad/s}$

Calculate the wave numbers (k):

$k_1 = 2\pi / \lambda_1 = 2\pi / 16000 \text{ m} \approx 0.000393 \text{ m}^{-1}$

$k_2 = 2\pi / \lambda_2 = 2\pi / 10000 \text{ m} \approx 0.000628 \text{ m}^{-1}$

$\Delta k = k_2 - k_1 \approx 0.000235 \text{ m}^{-1}$

Calculate the group velocity:

$V_g = \Delta\omega / \Delta k \approx 0.377 \text{ rad/s} / 0.000235 \text{ m}^{-1} = 1604.26 \text{ m/s}$.

Converting to kilometers per second:

V_g is approximately 1.6 km/s.

The resulting wave has a group velocity of about 1.6 km/s.