Combined Geo-Scientist (P)
Examination-2025

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO

T.B.C. : ESGC–B–GPS **Test Booklet Series**

A

Serial No. 1002201

TEST BOOKLET

Paper—II

(GEOPHYSICS)

Time Allowed : Two Hours **Maximum Marks : 300**

INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. **Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series A, B, C or D carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet. Any omission/discrepancy will render the Answer Sheet liable for rejection.**
3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside. *DO NOT* write *anything else* on the Test Booklet.
4. This Test Booklet contains **120** items (questions). Each item comprises four responses (answers). You will select the response which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose *ONLY ONE* response for each item.
5. You have to mark all your responses *ONLY* on the separate Answer Sheet provided. See directions in the Answer Sheet.
6. ***All*** items carry equal marks.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.
8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator *only the Answer Sheet.* You are permitted to take away with you the Test Booklet.
9. Sheets for rough work are appended in the Test Booklet at the end.
10. **Penalty for wrong answers :**
    THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE.
    (i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to that question will be deducted as penalty.
    (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.
    (iii) If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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1. Rheology is the study of

(a) mountain building process

(b) deformation and flow of solid materials

(c) deformation and flow of liquid materials and gases

(d) gravity effect of the Sun and the Moon

2. Consider the following nuclear electric quadrupole moments (Q) of the nuclei :

Nuclide	Q (in barn)
^{133}Cs	$-0\cdot003$
^{161}Dy	$+2\cdot401$
^{63}Cu	$-0\cdot209$

Which one of the following statements regarding the shape of these nuclei is correct?

(a) ^{63}Cu is prolate, ^{133}Cs is near spherical and ^{161}Dy is oblate.

(b) ^{63}Cu and ^{133}Cs are prolate and ^{161}Dy is oblate.

(c) ^{63}Cu and ^{161}Dy are oblate and ^{133}Cs is prolate.

(d) ^{63}Cu is oblate, ^{133}Cs is near spherical and ^{161}Dy is prolate.

3. The ratio of the nuclear magneton and Bohr magneton is

(a) 1836 *(b)* 1/1836

(c) 3672 *(d)* 1/3672

4. Which one of the following has maximum binding energy per nucleon?

(a) $^{4}_{2}He$

(b) $^{12}_{6}C$

(c) $^{58}_{28}Ni$

(d) $^{208}_{82}Pb$

5. A heavy nucleus goes to spontaneous symmetric fission. The energy released using the Bethe-Weizsäcker mass formula (neglecting pairing term) is given by

(a) $a_s A^{\frac{2}{3}}(1-2^{1/3})+a_c\frac{Z^2}{A^{\frac{1}{3}}}(1-2^{-2/3})$

(b) $a_s A^{\frac{2}{3}}(1+2^{1/3})+a_c\frac{Z^2}{A^{\frac{1}{3}}}(1-2^{2/3})$

(c) $a_s A^{\frac{2}{3}}(1+2^{1/3})+a_c\frac{Z^2}{A^{\frac{1}{3}}}(1+2^{-2/3})$

(d) $a_s A^{\frac{2}{3}}(1-2^{1/3})+a_c\frac{Z^2}{A^{\frac{1}{3}}}(1-2^{2/3})$

6. In the Sun, the fusion process generates energy using proton-proton cycle. Which one of the following reactions is dominating in the $^{3}_{2}He$ burning process?

(a) $^{3}_{2}He + {}^{4}_{2}He \rightarrow {}^{7}_{4}Be + \gamma$

(b) $^{3}_{2}He + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + p$

(c) $^{3}_{2}He + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + d$

(d) $^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2p$

7. Which one among the following laws can be used to determine the mass of a planet?

(a) Kepler's first law

(b) Kepler's second law

(c) Kepler's third law

(d) Newton's first law

8. When the ^{22}Na nucleus decays to ^{22}Ne, both electron capture decay and positive beta decay processes are energetically possible. If the Q-value of electron capture decay of ^{22}Na is 2·254 MeV, then the Q-value of positive beta decay of ^{22}Na is

(a) 3·276 MeV

(b) 2·254 MeV

(c) 1·743 MeV

(d) 1·232 MeV

9. The maximum Coulomb repulsive potential that the α-particle experiences in the α-decay of $^{212}_{84}Po$ is

[given, $R_0 = 1 \cdot 20$ fm]

(a) 22·24 MeV

(b) 26·21 MeV

(c) 30·24 MeV

(d) 34·24 MeV

10. The Compton scattering interaction of photon with matter results the creation of recoil electron and scattered gamma-ray photon. Which one of the following statements is correct about this process?

(a) Maximum kinetic energy of the recoil electron can be equal to the energy of initial photon.

(b) Maximum energy of the scattered photon can be greater than the energy of initial photon.

(c) Minimum kinetic energy of the recoil electron can be zero.

(d) Minimum energy of the scattered photon is much greater than $\frac{m_e c^2}{2}$.

11. A 2·556 MeV photon interacts with a medium via pair-production process. The energy of the single escape peak detected by the NaI(Tl) scintillation detector is

(a) 2·045 MeV

(b) 1·534 MeV

(c) 1·022 MeV

(d) 0·511 MeV

12. Consider that two isotopes of uranium $^{238}_{92}U$ and $^{235}_{92}U$ have abundance 93·0% and 7·0%, respectively in a planet. If these two isotopes were equal at the time of planet formation, then the age of the planet (in years) is

[given, the half-lives of $^{235}_{92}U$ and $^{238}_{92}U$ are 7×10^8 years and $4\cdot5\times10^9$ years, respectively; ln 93 = 4·533 and ln 7 = 1·946]

(a) $3\cdot1\times10^9$ (b) $5\cdot9\times10^8$

(c) $3\cdot1\times10^8$ (d) $5\cdot9\times10^9$

13. Secular variations in the geomagnetic field represent

(a) daily variations

(b) seasonal variations

(c) annual variations

(d) variations over decades or centuries

14. Naturally occurring radioactive isotope, which has only beta decay as primary mode of decay, is

(a) ^{186}Os (b) ^{232}Th

(c) ^{235}U (d) ^{176}Lu

15. The activity of 2·0 g of ^{226}Ra is

[given, the half-life of ^{226}Ra is 1600 years]

(a) $3\cdot7\times10^{10}$ Ci

(b) $7\cdot4\times10^{10}$ Ci

(c) 2×10^{10} Bq

(d) $7\cdot4\times10^{10}$ Bq

16. Which one of the following detectors is coupled with photomultiplier tube?

(a) Proportional counter

(b) GM counter

(c) Ionization counter

(d) NaI(Tl) scintillator

17. The wavelength of electron having kinetic energy 100 eV is

(a) 0·123 nm

(b) 0·132 nm

(c) 0·231 nm

(d) 0·312 nm

18. Electromagnetic waves are travelling in vacuum. The relationship between group velocity (v_g) and phase velocity (v_p) is

(a) $v_g < v_p$ (b) $v_g = v_p^2$

(c) $v_g > v_p$ (d) $v_g = v_p$

19. Which one of the following electron experiments does ***not*** confirm the wave nature of the electron?

(a) Davisson and Germer experiment

(b) G. P. Thomson's experiment

(c) Photoelectric effect

(d) Young's double-slit experiment

20. The Balmer series of hydrogen spectrum is labelled as H_α, H_β, H_γ, H_δ, ... for $n = 3, 4, 5, 6, \ldots$, respectively. The spectrum line that has blue colour is

(a) H_α line (b) H_β line

(c) H_γ line (d) H_δ line

21. The wave number of singly ionized helium atom for the first spectral line of Balmer series is

(a) $0 \cdot 0381 \times 10^7 \text{ m}^{-1}$

(b) $0 \cdot 1524 \times 10^7 \text{ m}^{-1}$

(c) $0 \cdot 3048 \times 10^7 \text{ m}^{-1}$

(d) $0 \cdot 6096 \times 10^7 \text{ m}^{-1}$

22. Match List–I with List–II and select the correct answer using the code given below the Lists :

List–I [Microwave band]	*List–II [Frequency (in GHz)]*
1. C-band	A. 0·3–1
2. K-band	B. 1–2
3. Ka-band	C. 2–4
4. Ku-band	D. 4–8
5. L-band	E. 8–12·5
6. P-band	F. 12·5–18
7. S-band	G. 18–26·5
8. X-band	H. 26·5–40

Code :

(a)	C	D	E	F
	2	5	6	8
(b)	C	D	E	F
	3	7	2	5
(c)	C	D	E	F
	7	1	8	4
(d)	C	D	E	F
	5	7	4	6

23. Which one of the following parameters does ***not*** govern the texture in an optical image?

(a) Scale

(b) Shadow

(c) Spatial resolution

(d) Dielectric constant

24. The momentum of a free non-relativistic particle is

(a) directly proportional to square root of its energy

(b) inversely proportional to square root of its energy

(c) directly proportional to square of its energy

(d) inversely proportional to square of its energy

25. Match List–I with List–II and select the correct answer using the code given below the Lists :

List–I [Electromagnetic radiation]	*List–II [Frequency range (in Hz)]*
A. Gamma rays	1. 10^9–10^{12}
B. Infrared	2. 10^{12}–10^{14}
C. Microwave	3. 10^{15}–10^{17}
D. Ultraviolet	4. 10^{19}–10^{22}

Code :

(a)	A	B	C	D
	3	1	2	4
(b)	A	B	C	D
	3	2	1	4
(c)	A	B	C	D
	4	1	2	3
(d)	A	B	C	D
	4	2	1	3

26. In an atom, a photon is emitted during a transition from energy level E_1 to energy level E_2. If the difference between E_1 and E_2 is 4·136 eV, then the corresponding photon wavelength is approximately

[given, the Planck's constant is $4 \cdot 136 \times 10^{-15}$ eVs and the speed of light is 3×10^8 m/s]

(a) 300 nm

(b) 30·0 nm

(c) 3·00 nm

(d) 0·30 nm

27. For blackbody radiation, the pressure (P) is given by the relation

(a) $P = \frac{4\sigma T^4}{c}$

(b) $P = \frac{4\sigma T^4}{3c}$

(c) $P = \frac{3\sigma T^4}{4c}$

(d) $P = \frac{\sigma T^4}{3}$

[where T is temperature, σ is Stefan's constant and c is the distance travelled by radiation in unit time]

28. Consider the following statements regarding spectral distribution of energy for blackbody radiation :

1. For given wavelength, the energy density decreases with increase in temperature.
2. At each temperature, the distribution of energy shows a maximum, which shifts to longer wavelength as temperature increases.
3. At each temperature, the distribution of energy shows a maximum, the product of wavelength and temperature at the maximum is constant value.

Which of the statements given above is/are correct?

(a) 1 only

(b) 1 and 2

(c) 3 only

(d) 1 and 3

29. For shorter wavelength limit, the Planck's radiation law becomes

(a) Rayleigh-Jeans law

(b) Wien's radiation law

(c) Stefan's law

(d) Kirchhoff's law

30. A nuclear fission explosion produces a fireball which can be approximated as a blackbody having electromagnetic radiation power 12·56 MW. The electromagnetic radiation intensity at 5 km distance is

(a) 25 MW/m^2

(b) 0·04 MW/m^2

(c) 25 W/m^2

(d) 0·04 W/m^2

31. Consider the following thermodynamic relation :

$$dU = T\,dS - P\,dV$$

[where U = internal energy, S = entropy, T = temperature, P = pressure and V = volume]

Which one of the following pairs is correct, as obtained from the above thermodynamic relation?

(a) $T = -(\partial U/\partial S)_V$ and $P = -(\partial U/\partial V)_S$

(b) $T = +(\partial U/\partial S)_V$ and $P = +(\partial U/\partial V)_S$

(c) $T = +(\partial U/\partial S)_V$ and $P = -(\partial U/\partial V)_S$

(d) $T = -(\partial U/\partial S)_V$ and $P = +(\partial U/\partial V)_S$

32. Which one of the following functions is defined by the 2nd law of thermodynamics?

(a) Enthalpy

(b) Entropy

(c) Internal energy

(d) Pressure

33. A heat pump uses 2 kW of electrical power supply to heat a house at 25 °C when the outside temperature is 0 °C. The maximum heat flow rate is

(a) 23·84 kJ/s

(b) 11·92 kJ/s

(c) 2·0 kJ/s

(d) 0·17 kJ/s

34. Consider two isolated protons at a distance d apart. Suppose their electrostatic force of repulsion is equal in magnitude to the gravitational force acting on either proton at the surface of the Earth. In terms of the charge and mass of a proton, e and m, respectively, the free space permittivity ε_0, and the acceleration due to gravity on the Earth's surface, g, the value of d is

(a) $e/(mg\sqrt{4\pi\varepsilon_0})$

(b) $mge/\sqrt{4\pi\varepsilon_0}$

(c) $e/\sqrt{4\pi\varepsilon_0 mg}$

(d) $(mg\sqrt{4\pi\varepsilon_0})/e$

35. An electric dipole consists of charges of magnitude 2·0 nC, separated by 6·0 μm. It is placed in an electric field of magnitude 1000 N/C. The magnitude of difference between the potential energies for dipole orientations parallel and anti-parallel to the electric field is

(a) $1{\cdot}2\times10^{-10}$ joule

(b) $2{\cdot}8\times10^{-12}$ joule

(c) $1{\cdot}4\times10^{-12}$ joule

(d) $2{\cdot}4\times10^{-11}$ joule

36. Two identical spherical water droplets, each of radius a and carrying charge q, combine to form a single spherical water drop, the electric potential at the surface of which is V. In terms of q, a and the free space permittivity ε_0, the value of V is

(a) $2^{-4/3}q/(\pi\varepsilon_0 a)$

(b) $2^{-2/3}\pi q/(\varepsilon_0 a)$

(c) $2^{2/3}q/(\pi\varepsilon_0 a)$

(d) $2^{4/3}\pi q/(\varepsilon_0 a)$

37. A long straight wire, carrying a steady current I, lies on the surface of the Earth. The Earth's magnetic field, at the location of the wire, has a value $40\,\mu T$, and is horizontal and due North. Given the free space permeability $\mu_0 = 4\pi \times 10^{-7}$ H/m, the resultant magnetic field would vanish 8 cm above the wire, if

(a) $I = 16$ A

(b) $I = 12$ A

(c) $I = 40$ A

(d) $I = 20$ A

38. A point charge q is imbedded at the centre of a sphere of linear dielectric material of dielectric constant K. The total bound charge on the surface of the sphere is

(a) $Q_b = q/K$

(b) $Q_b = q(1-K)/K$

(c) $Q_b = q/(K-1)$

(d) $Q_b = q(K-1)/K$

39. Suppose that a portion q of the total charge Q on a sphere is transferred to a nearby sphere which has been electrically neutral initially. If the two spheres are tiny enough to be treated almost as particles, then the electrostatic force between them, after the charge transfer, would be maximum when

(a) $q = Q/4$

(b) $q = Q^2/8$

(c) $q = Q/2$

(d) $q = 2Q^2/9$

40. A particle of charge q and mass m, moving with an initial speed v in the yz-plane, is subjected to uniform electric and magnetic fields of magnitudes E and B, respectively. If the magnetic field is in the x-direction, and the particle accelerates in the x-direction as well, then the magnitude of the acceleration is

(a) $q(E - vB)/m$

(b) $q\sqrt{E^2 - v^2B^2}\,/m$

(c) $q(E + vB)/m$

(d) $q\sqrt{E^2 + v^2B^2}\,/m$

41. A particle of charge q and mass m is circulating in a plane which is at an angle of 45° to a uniform magnetic field of magnitude B. The frequency of the revolution is

(a) $qB/(\sqrt{8}\pi m)$

(b) $4qB/(\pi m)$

(c) $2qB/(\sqrt{3}\pi m)$

(d) $qB/(2\pi m)$

42. An unknown charge sits on a conducting solid sphere of radius $L/(2\pi)$. If the magnitude of the electric field at a distance L/π from the centre of the sphere is E, then the net charge on the sphere is

(a) $4\pi\varepsilon_0 L^2 E$

(b) $4\varepsilon_0 L^2 E/\pi$

(c) $\varepsilon_0 L^2 E/\pi^2$

(d) $\pi\varepsilon_0 E/L^2$

43. A long cylindrical wire of radius R carries a current I distributed uniformly over the cross-section. Let the magnetic field, due to the current I, be of magnitude B at the surface of the wire. The distances from the surface, outside and inside the wire, at which the magnetic field is of magnitude $B/4$, are respectively

(a) $4R$ and $R/4$

(b) $2R$ and $3R/4$

(c) $2R$ and $R/2$

(d) $3R$ and $3R/4$

44. A surveyor is using a magnetic compass at a distance d below a power line in which there is a steady current of 100 A. The free space permeability is $\mu_0 = 4\pi \times 10^{-7}$ T-m/A, and the horizontal component of the Earth's magnetic field at the site is given to be 20 μT. The deflection of the compass needle due to power line would be as large as 9 degrees, if d is equal to

$$\left[\text{Deflection} = \frac{\text{Magnetic field due to power line}}{\text{Earth's magnetic field}}\right]$$

(a) $(2/\pi)$ m

(b) 2π m

(c) $(20/\pi)$ m

(d) 20π m

45. The magnetic flux through a coil is given as a function of time t as

$$\Phi_B(t) = \alpha t - \beta t^3$$

where α and β are certain constants. If the induced e.m.f. is zero at an instant of time T, then at a later instant $3T$, this e.m.f. would be

(a) 3α

(b) 8α

(c) 4α

(d) 9α

46. A generator consists of 100 turns of wire, which is formed into a square loop of side 30 cm, and placed entirely in a uniform magnetic field of 4 T in magnitude. The maximum e.m.f. induced when the loop is spun at 1000 revolutions per minute, about an axis perpendicular to the magnetic field, is

(a) 1200π V

(b) 600π V

(c) 6π V

(d) 12π V

47. Consider a point charge Q moving in a straight line, with a constant speed v, towards a small loop of area α which is perpendicular to the direction of motion of the charge. The magnitude of displacement current through the loop, when it is at a very short distance x from the charge, can be expressed as

(a) $Q\alpha v/(2\pi x^3)$

(b) $Qx^2 v/(4\alpha)$

(c) $Qx^3 v/(2\pi\alpha)$

(d) $Q\alpha v/(4\pi x)$

48. A conducting loop of wire of resistance R and enclosing an area α is placed perpendicular to a magnetic field B for a short time interval T and then removed far away. The charge that flows through any cross-section of the wire, during the process, is

(a) $Q = \alpha B/(RT)$

(b) $Q = BT/(\alpha R)$

(c) $Q = \alpha BT/R$

(d) $Q = \alpha B/R$

49. In a region of space, consider a square loop of wire with vertices at $(x = 0, y = 0)$, $(x = a, y = 0)$, $(x = a, y = a)$ and $(x = 0, y = a)$. If there is a magnetic field in this region, given by $\vec{B} = \beta t^2 y^3 \hat{z}$, where β is a constant and $\hat{z}$ is the unit vector along the z-direction, then the e.m.f. induced in the loop would be

(a) $\varepsilon = -\beta t a^5/2$

(b) $\varepsilon = -\beta t a^4/4$

(c) $\varepsilon = -\beta t^3 a^5/5$

(d) $\varepsilon = -\beta t^3 a^3/3$

50. A parallel-plate capacitor of plate area A and plate separation d is charged by a time-varying current. Suppose there is a plane surface of area $A/2$, parallel to the plates, and situated symmetrically between them. If the charge on the capacitor varies as $Q = Q_0 \exp[-t/\tau]$, where Q_0 and τ are constants, then the displacement current through this surface is

(a) $-(2Q_0/\tau)\exp[-t/\tau]$

(b) $-(Q_0/2\tau)\exp[-t/\tau]$

(c) $-2Q_0\tau\exp[-2t/\tau]$

(d) $-(Q_0/\tau)\exp[-2t/\tau]$

51. Consider the propagation of an electromagnetic wave with a frequency ν in a certain piece of glass. Let the peak amplitude of the electric field in the wave be given by

$$E_0 = (2+\mu_r)cB_0/2$$

where B_0 is the peak amplitude of the corresponding magnetic field, μ_r is the relative permeability, and c is the speed of light in vacuum. The dielectric constant for glass at the frequency ν is

(a) $\dfrac{4}{\mu_r(\mu_r+2)^2}$

(b) $\dfrac{2}{\mu_r(\mu_r+2)}$

(c) $\dfrac{\mu_r}{2(\mu_r+2)}$

(d) $\dfrac{4\mu_r}{(\mu_r+2)^2}$

52. An electromagnetic wave from a radio station passes perpendicularly through an open window of area 0·5 sq. m. Suppose that at the window, the electric field of the wave has a peak amplitude 0·02 V/m. The energy the wave would carry through the window during a 20-second commercial can therefore be expressed in terms of the free space permittivity ε_0 and the speed of light in free space, c, as

(a) $5\varepsilon_0 c \times 10^{-3}$ J

(b) $2\varepsilon_0 c \times 10^{-6}$ J

(c) $2\varepsilon_0 c \times 10^{-3}$ J

(d) $5\varepsilon_0 c \times 10^{-6}$ J

53. Match List–I with List–II and select the correct answer using the code given below the Lists :

List–I (Operation)	*List–II (Naming/Result)*
A. Vector product of two vectors vanishes	1. self-product
B. Scalar product of a vector with itself, is called	2. commutative
C. Vector product of two vectors is	3. when components of vectors are parallel
D. Scalar product of two vectors is	4. not commutative

Code :

	A	B	C	D
(a)	2	4	1	3
(b)	2	1	4	3
(c)	3	1	4	2
(d)	3	4	1	2

54. Let the force $\vec{F} = \dfrac{-m}{r^3}(x\hat{i} + y\hat{j} + z\hat{k})$. The curl of $\vec{F}$ is

(a) $-\dfrac{3m}{r^2}(x\hat{i} + y\hat{j} + z\hat{k})$

(b) $+\dfrac{3m}{r^2}(x\hat{i} + y\hat{j} + z\hat{k})$

(c) $-3mr^4(x\hat{i} + y\hat{j} + z\hat{k})$

(d) zero

55. Consider the following statements :

1. Gradient of a scalar function is a scalar.
2. Divergence of a vector field is a scalar quantity.
3. For solenoidal vector, the divergence of vector field is zero.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 1 and 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

56. Let

$$A = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

If $A = (I - S)(I + S)^{-1}$, then the matrix S is

[where I is identity matrix]

(a) $\begin{bmatrix} 0 & -\tan(\theta/2) \\ \tan(\theta/2) & 0 \end{bmatrix}$

(b) $\begin{bmatrix} 0 & -\cot(\theta/2) \\ \cot(\theta/2) & 0 \end{bmatrix}$

(c) $\begin{bmatrix} 0 & \tan(\theta/2) \\ \tan(\theta/2) & 0 \end{bmatrix}$

(d) $\begin{bmatrix} 0 & \cot(\theta/2) \\ \cot(\theta/2) & 0 \end{bmatrix}$

57. The eigenvalues of the matrix

$$S = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

are

(a) $-1, 0, 2$ *(b)* $0, -1, 2$

(c) $0, 1, 2$ *(d)* $1, 1, 2$

58. Consider that a planet has radius four times the radius of the Earth. If this planet has the same surface gravity as the Earth, then its escape speed is

(a) equal to the escape speed of the Earth

(b) two times the escape speed of the Earth

(c) three times the escape speed of the Earth

(d) four times the escape speed of the Earth

59. Conservative plate margins are marked by abundance of

(a) normal fault

(b) reverse fault

(c) strike-slip fault

(d) oblique-slip fault

60. Theoretical physics has unified the combination of two/three fundamental interactions together. The term 'grand unified interaction' means

(a) unification of electromagnetic and weak forces

(b) unification of electromagnetic, weak and strong forces

(c) unification of electromagnetic and strong forces

(d) unification of all fundamental forces

61. Consider the following statements regarding one-dimensional elastic collision of two particles with masses m_1 and m_2:

1. When $m_1 = m_2$, the particles interchange their velocities on collision.

2. When $m_1 << m_2$ and the particle with mass m_2 is initially at rest, the latter begins to move and the particle with mass m_1 comes to rest.

3. When $m_1 >> m_2$ and the particle with mass m_2 is initially at rest, the velocity of the particle with mass m_1 remains unchanged on collision.

Which of the statements given above is/are correct?

(a) 1 only

(b) 1 and 2

(c) 2 and 3

(d) 1 and 3

62. A rigid body, in three space dimensions, is rotated by an angle $\frac{\pi}{2}$ in anti-clockwise direction around the Z-axis. The same body is then rotated by $\frac{\pi}{3}$ in anti-clockwise direction around X-axis, subsequently the body is rotated by $\frac{\pi}{6}$ in anti-clockwise direction around X-axis. If the coordinates to begin with are represented by a column vector $\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$, then the transformed coordinates after all the above-mentioned rotations are represented as

(a) $\begin{pmatrix} -Z \\ Y \\ -X \end{pmatrix}$ *(b)* $\begin{pmatrix} Y \\ Z \\ X \end{pmatrix}$

(c) $\begin{pmatrix} -Z \\ X \\ -Y \end{pmatrix}$ *(d)* $\begin{pmatrix} -Z \\ X \\ Y \end{pmatrix}$

63. In a solid sphere, the ratio of moment of inertia about its diameter to the moment of inertia about a tangent is

(a) 0·286 *(b)* 0·600

(c) 1·667 *(d)* 3·500

64. A beam of particles with a proper lifetime of 5 microsecond moves through the laboratory at a speed of 2×10^8 m s^{-1}. The average distance traversed by the particles before disintegration is

(a) $3\sqrt{5} \times 10^2$ m

(b) $5\sqrt{3} \times 10^2$ m

(c) $6\sqrt{5} \times 10^2$ m

(d) $10\sqrt{3} \times 10^2$ m

65. Consider the following statements regarding geophysical methods :

1. These methods are applied for geophysical fields, namely gravity, magnetic, electromagnetic and seismic waves field.
2. The forward problem solution makes possible to predict geophysical data for geological structures.
3. In inverse problems, model parameters are determined for a model using geographical data.

Which of the statements given above are correct?

(a) 1, 2 and 3

(b) 1 and 2 only

(c) 2 and 3 only

(d) 1 and 3 only

66. Weighted least-square method is used

(a) when all observations have same accuracy

(b) when some observations have more precision but errors are equal

(c) when some observations have more accuracy than others

(d) when all observations have same precision and errors are equal

67. For the binomial distribution and its normal approximation with $n = 100$ trials and probability of occurrence $p = 0 \cdot 5$, the values of mean and standard deviation are

(a) 50 and 10

(b) 60 and 10

(c) 50 and 5

(d) 60 and 5

68. Which one of the following is ***not*** an example of discrete random variable?

(a) Outcomes of coin tosses

(b) Outcomes of tossing a die

(c) Outcomes of finding electron in atom

(d) Outcomes of measuring radioactive alpha decay

69. For asymmetric distribution, mode and mean are 5 and 8, respectively. The value of median is

(a) 5

(b) 6

(c) 7

(d) 8

70. Which one of the following is a linear differential equation?

(a) $y' = \cot(y)$

(b) $yy' = 1$

(c) $y'^2 = xy$

(d) $y' = x$

71. Consider the second-order linear differential equation

$$\frac{d^2y}{dx^2} + a_1\frac{dy}{dx} + a_2 y = 0$$

where a_1 and a_2 are constants. The solution of this equation, when both roots of the auxiliary equation are real and equal, is

(a) $y = (Ax + B)e^{mx}$, m is the root and A and B are constants

(b) $y = (Ax + Bx)e^{mx}$, m is the root and A and B are constants

(c) $y = (Ax - B)e^{mx}$, m is the root and A and B are constants

(d) $y = (Ax - Bx)e^{mx}$, m is the root and A and B are constants

72. Poisson partial differential equation is

(a) linear and homogeneous

(b) linear and inhomogeneous

(c) non-linear and homogeneous

(d) non-linear and inhomogeneous

73. The Wadati-Benioff seismic zone is related to

(a) constructive plate margins

(b) destructive plate margins

(c) plate interiors

(d) conservative plate margins

74. Match List–I with List–II and select the correct answer using the code given below the Lists (symbols have their usual meanings) :

List–I (Name)	*List–II (Form of equation)*
A. Diffusion equation	1. $\nabla^2\psi = \rho$
B. Laplace's equation	2. $\nabla^2\psi = \frac{1}{h^2}\frac{\partial\psi}{\partial t}$
C. Wave equation	3. $\nabla^2\psi = 0$
D. Poisson's equation	4. $\nabla^2\psi = \frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2}$

Code :

(a)	A	B	C	D
	2	3	4	1
(b)	A	B	C	D
	2	4	3	1
(c)	A	B	C	D
	1	3	4	2
(d)	A	B	C	D
	1	4	3	2

75. Which one of the following is the correct relation for Newton-Raphson formula?

(a) $x_{n+1} = x_n + \frac{f(x_n)}{f'(x_n)}$

(b) $x_{n+1} = x_n + \frac{f'(x_n)}{f(x_n)}$

(c) $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$

(d) $x_{n+1} = x_n - \frac{f'(x_n)}{f(x_n)}$

76. Using the linear interpolation method, the root of the function

$$f(x) = x^2 - x - 2 = 0$$

in the range $1 < x < 3$ after the 2nd iteration is

(a) 1·6667

(b) 1·7778

(c) 1·909

(d) 2·121

77. Consider

$$S_n = 1^3 + 2^3 + 3^3 + \ldots + n^3$$

The value of the third forward difference $\Delta^3 S_n$ using Newton's forward difference formula is

(a) $4n + 12$

(b) $6n + 18$

(c) $6n + 12$

(d) $4n + 8$

78. The Euler method for solving ordinary differential equations uses the slope at the starting point of an interval to estimate the next value of the function. The Euler method is a

(a) first-order Runge-Kutta method

(b) second-order Runge-Kutta method

(c) third-order Runge-Kutta method

(d) fourth-order Runge-Kutta method

79. A hexagonal length of pipe used to convey the rotatory movement to the drill string and bit is called

(a) kelly bushing

(b) draw-works

(c) kelly

(d) riser

80. In local magnetic survey, the latitude correction at magnetic equator is

(a) zero

(b) 5 nT/km

(c) 0·5 nT/km

(d) 50 nT/km

81. Which one of the following magnetometers has the highest precision?

(a) Fluxgate magnetometer

(b) Proton precision magnetometer

(c) Optically pumped magnetometer

(d) Torsion head magnetometer

82. What will be the approximate value of gravity anomaly of an infinite horizontal sheet of density 2·62 g/cm^3 and thickness 132 cm lying in the surrounding material of density 2·43 g/cm^3?

(a) 13274×10^{-8} gal

(b) 14489×10^{-8} gal

(c) 582×10^{-8} gal

(d) 1051×10^{-8} gal

83. Which one of the following electrode arrays is the best to determine the depth and resistivity for flat-lying layered sedimentary rock structures?

(a) Wenner

(b) Schlumberger

(c) Dipole-Dipole

(d) Pole-Dipole

84. What will be the total magnetic field for a given Larmor frequency of $(9/\pi)$ kHz and gyromagnetic ratio for protons as 0·30 Hz/nT?

(a) 25000 nT

(b) 65000 nT

(c) 56000 nT

(d) 60000 nT

85. Which one of the following statements regarding the plot of real and imaginary components of response function with response parameter (Q) in electro-magnetic method is correct?

(a) The real component is greater than the imaginary component for $Q < 1$.

(b) The imaginary component is greater than the real component for $Q > 1$.

(c) The real component is greater than the imaginary component for $Q > 1$.

(d) The real and imaginary components follow the same trend for all possible values of Q.

86. The resistivity of a clean, consolidated hydrocarbon bearing sandstone formation is 10 Ω m. The rock porosity and formation water resistivity are 15% and 0·05 Ω m, respectively. What will be the hydrocarbon saturation of the formation if the saturation exponent (n) is 2?

(a) 42%

(b) 21%

(c) 58%

(d) 29%

87. Match List–I with List–II and select the correct answer using the code given below the Lists :

List–I (Log type)	*List–II (Formation property/ content)*
A. Microlaterolog	1. The interval transit time of a sound wave
B. Neutron log	2. Primarily responds to the amount of hydrogen in the formation
C. Litho-Density log	3. Resistivity of the flushed zone
D. Sonic log	4. Bulk density and photoelectric absorption index of the formation

Code :

	A	B	C	D
(a)	3	2	4	1
(b)	3	4	2	1
(c)	1	2	4	3
(d)	1	4	2	3

88. The difference in travel time for a given reflection for two geophone locations, over a horizontal reflector is known as

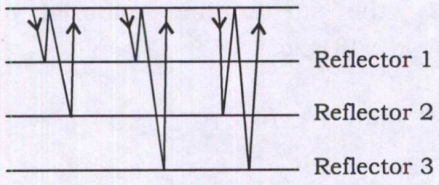
(a) moveout

(b) checkout

(c) stacking

(d) dip correction

89. Which type of reflection of seismic waves is shown in the diagram given below for ray paths in a model with three reflectors?



(a) Primary reflections

(b) First multiples

(c) Peg-leg multiples

(d) Inter-bed multiples

90. Consider the following statements regarding seismic attributes analysis :

1. In clastic sections, the lowering of the acoustic impedance of a reservoir often produces a high amplitude reflection called as bright spot.
2. When the acoustic impedance of a water-filled reservoir is appreciably larger than that of the adjacent rock, the lowering of the acoustic impedance by hydrocarbon produces a dim spot.
3. A horizontal gas-oil, gas-water or oil-water contact may produce a distinct reflection, especially where the reservoir is thick, such reflection is called as flat spot.

Which of the statements given above are correct?

(a) 1, 2 and 3

(b) 1 and 2 only

(c) 2 and 3 only

(d) 1 and 3 only

91. A seismic SH-wave is incident from medium-1 to medium-2 at the critical angle (α). What is the ratio of wave speeds of medium-1 to medium-2?

(a) $\sin \alpha$

(b) $\sin^2 \alpha$

(c) $\sin\left(\frac{\pi}{2} - \alpha\right)$

(d) $\frac{1}{\sin \alpha}$

92. A seismic ray traverses through a two-layered Earth medium. The velocity and density for the first layer are 2·7 km/s and 2400 kg/m^3, and those for the second layer are 3·0 km/s and 2300 kg/m^3, respectively. The reflection and transmission coefficients will be

(a) 0·03 and 0·97, respectively

(b) 0·97 and 0·03, respectively

(c) 0·15 and 0·85, respectively

(d) 0·85 and 0·15, respectively

93. A layer with a seismic wave velocity of 1500 m/s and a thickness of 100 m lies above another layer with a velocity of 3000 m/s. What is the expected crossover distance for the critically refracted waves?

(a) 346·4 m

(b) 546·4 m

(c) 746·4 m

(d) 946·4 m

94. A geophysical signal is being recorded at a sampling rate of 1 sample per 2 milli-second. The temporal variations in the signal occurring at frequency around 625 Hz will be

(a) faithfully reproduced from the sampled data

(b) reproduced with aliasing of higher frequencies down to lower frequencies

(c) reproduced but at a higher frequency

(d) non-reproducible from sampled data

95. Which one of the following conditions is correct for exhibiting aliasing effect in a signal?

(a) Sampling rate > Nyquist rate

(b) Sampling rate = 0

(c) Sampling rate < Nyquist rate

(d) Nyquist rate = 0

96. Which of the following pairs are ***not*** correctly matched?

(Filter)		*(Filtering)*
1. Low-pass filters	:	Reject high frequencies
2. High-pass filters	:	Pass high frequencies
3. Band-pass filters	:	Pass all the frequencies
4. Band-reject filters	:	Reject all the frequencies

Select the answer using the code given below.

(a) 1, 3 and 4

(b) 3 and 4 only

(c) 1 and 2 only

(d) 1, 2 and 3

97. The Fourier transform of the rectangular function $\Pi\left(\frac{x-3}{2}\right)$ is

(a) $\frac{2}{3}e^{-3\iota\omega}\cdot\sin\left(\frac{2\omega}{3}\right)$

(b) $2e^{-3\iota\omega}\cdot\sin(2\omega)$

(c) $2e^{-3\iota\omega}\cdot\sin\left(\frac{2\omega}{3}\right)$

(d) $3e^{-3\iota\omega}\cdot\sin(2\omega)$

98. The convolution of two finite length sequences $x_n = \{1, 0, -2\}$ and $y_n = \{1, -1\}$ is

(a) $\{-1, 1, 2, -2\}$

(b) $\{1, -1, -2, 2\}$

(c) $\{1, 0, -2, 2\}$

(d) $\{1, -2, -1, 2\}$

99. The function

$$\delta(t) = \begin{cases} 1, & t = 0 \\ 0, & t \neq 0 \end{cases}$$

is known as

(a) unit-step function

(b) Dirac-delta function

(c) unit rectangular function

(d) ramp function

100. Which one of the following statements regarding age determination of rocks using radioisotopes is ***not*** correct?

(a) Sr/Rb method is useful in determining the age of Pre-cambrian rocks.

(b) ^{40}K measurements determine the age since the temperature of the rock dropped below 50 °C.

(c) ^{18}O to ^{16}O ratio is indicator of paleo-temperatures in oceans.

(d) K/Ar method is useful in determining age from about 50 thousand years to about 3·5 billion years.

101. Which one of the following planets has ***no*** significant global magnetic field at present?

(a) Jupiter

(b) Uranus

(c) Mars

(d) Neptune

102. The angle between the ecliptic plane and equatorial plane is known as

(a) angle of inclination

(b) angle of obliquity

(c) angle of declination

(d) angle of azimuth

103. The latitude correction in gravity data is minimum at

(a) poles only

(b) equator only

(c) both poles and equator

(d) 45° latitude

104. The maximum tidal effect of the Sun in comparison to the Moon is only about

(a) 80%

(b) 45%

(c) 30%

(d) 10%

105. The magnetism acquired over a short time in a strong magnetic field at a constant temperature is known as

(a) isothermal remanent magnetization

(b) viscous remanent magnetization

(c) chemical remanent magnetization

(d) anhysteretic remanent magnetization

106. Which one of the following minerals has the highest magnetic permeability?

(a) Magnetite

(b) Pyrrhotite

(c) Hornblende

(d) Quartz

107. The inclination of geocentric dipole to the Earth's rotation axis is about

(a) 8·2°

(b) 11·2°

(c) 18·2°

(d) 23·5°

108. The approximate ratio of the Earth's total magnetic field at the poles to that at the equator is

(a) 1 : 4

(b) 1 : 3

(c) 1 : 2

(d) 2 : 1

109. The bulk modulus, shear modulus and bulk density of materials in a medium are 16 GPa, 13 GPa, 2·25 g/cm^3, respectively. What would be the Poisson's ratio of the medium?

(a) 0·06

(b) 0·10

(c) 0·18

(d) 0·27

110. The empirical relationship of P-wave velocity V (ft/s) as a function of age (T) and depth z (ft) of the burial is $V = K(zT)^{1/6}$. This relationship is called

(a) Faust's equation

(b) Wyllie's equation

(c) Archie's law

(d) Hubble's law

111. The particle displacement (u) for a seismic wave travelling in the positive x-direction is $u = A\exp[i(kx - \omega t)]$. If there is no attenuation, the wave number k is given by

(a) ω / x

(b) ω / c

(c) $k + ix$

(d) ω / y

[where A = amplitude, ω = frequency and c = wave speed]

112. The seismic phase PKP indicates

(a) P-wave refracted through the outer liquid core

(b) P-wave reflected from the outer liquid core

(c) P-wave reflected from the core-mantle boundary

(d) P-wave reflected from the inner core

113. Which one of the following statements is ***not*** correct?

(a) At the Lehmann discontinuity, an abrupt decrease of P- and S-wave velocities by 3–4% is observed.

(b) Below the Moho discontinuity, P-wave velocity exceeds 7·6 km/s.

(c) In the low-velocity layer, the velocity decreases with increasing depth.

(d) The core-mantle boundary is called as Gutenberg discontinuity.

114. The P-wave velocity becomes maximum inside the Earth near

(a) Mohorovičić discontinuity

(b) Conrad discontinuity

(c) Gutenberg discontinuity

(d) Lehmann discontinuity

115. The absence of S-waves beyond an epicentral distance of 105° and existence of P-wave shadow zone in the epicentral distance range 105°–143° on the Earth indicates that the Earth has a/an

(a) mantle that creeps

(b) solid outer core

(c) silicate-rich crust

(d) inner core within a liquid outer core

116. Which one of the following statements regarding the radiogenic heat inside the Earth is correct?

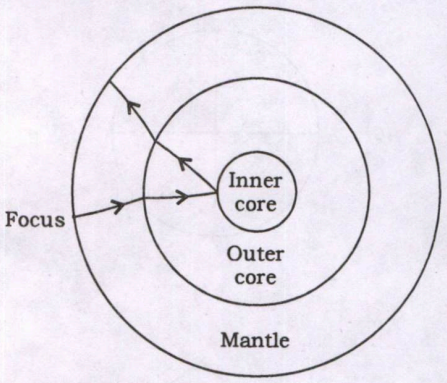
(a) Radiogenic heat flow is more in upper crust than rest of lithosphere.

(b) Radiogenic heat flow is less in upper crust than rest of lithosphere.

(c) Radiogenic heat flow is same in upper crust and rest of lithosphere.

(d) No radiogenic heat flow occurs in crust.

117. The seismic wave path of reflected and refracted P-wave phases in the following diagram shows



(a) PKCKP

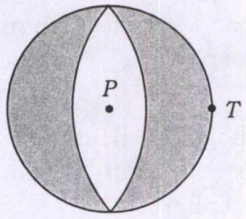
(b) PKiKP

(c) PKIKP

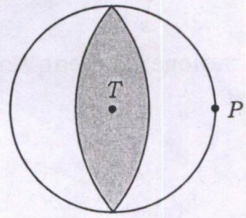
(d) PKcKP

118. Which one of the following is a correct representation of strike-slip tectonic fault?

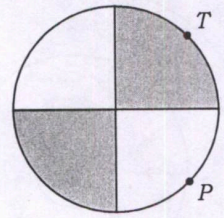
(a)



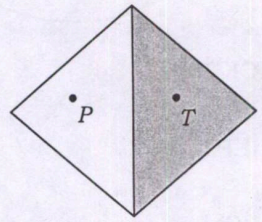
(b)



(c)



(d)



[where T = tension and P = compression]

119. An intraplate earthquake in 2001 and reservoir-induced earthquake in 1967 occurred in which two States of India?

(a) Assam and Gujarat, respectively

(b) Arunachal Pradesh and Bihar, respectively

(c) Kerala and Uttar Pradesh, respectively

(d) Gujarat and Maharashtra, respectively

120. What will be the intensity value on the European Macroseismic Scale (EMS) 1998 to describe the effects of earthquakes as 'very destructive'?

(a) IX

(b) X

(c) XI

(d) XII

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