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T.B.C. : SBVP-B-GPH

Test Booklet Series

A

Serial

1001777

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 Code 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. Consider the following statements regarding the different geophysical methods :

   1. Seismic methods using ambient noise come under passive seismology.
   2. Gravity and magnetic methods are wave field methods.
   3. Seismic exploration methods investigate structures shallower than the earthquake seismology.

   Which of the statement(s) given above is/are correct ?

   (a) 1 only
   (b) 1 and 3 only
   (c) 2 and 3 only
   (d) 1, 2 and 3

2. Consider the following statements regarding different geophysical methods :

   1. The time variation of magnetic field is complex whereas the gravity field is smooth.
   2. The study of the Earth's magnetism is the oldest branch of geophysics.
   3. Exploration seismology is an offspring of earthquake seismology.

   Which of the statements given above are correct ?

   (a) 1, 2 and 3
   (b) 1 and 3 only
   (c) 2 and 3 only
   (d) 1 and 2 only

3. Bode's law gives the distance of a planet from the Sun. Which one of the following does ***not*** follow this relationship ?

   (a) Venus
   (b) Asteroid belt
   (c) Uranus
   (d) Neptune

4. What is the major constituent in the core of Vesta asteroid ?

   (a) Iron
   (b) Nickel
   (c) Aluminium
   (d) Copper

5. After passing through the shock front, the solar wind is diverted around the Earth in a region of turbulent motion called :

   (a) Magnetosheath
   (b) Magnetosphere
   (c) Magnetopause
   (d) Van Allen belts

6. Which one of the following statements regarding the angle of obliquity and eccentricity of Earth's orbit is ***not*** correct ?

   (a) Eccentricity varies with a period of about 1,00,000 years.
   (b) Obliquity varies with a period of about 41,000 years.
   (c) The difference in insolation between summer and winter seasons is high for very small values of eccentricity.
   (d) Obliquity is the main factor that determines the seasonal difference between summer and winter in each hemisphere.

7. The remanent magnetization related to the meteoritic impact is :

(a) Piezo remanent magnetization

(b) Shock remanent magnetization

(c) Anhysteretic remanent magnetization

(d) Isothermal remanent magnetization

8. The horizontal component of Earth's magnetic field at a place on the Earth's surface is 1·5 times its vertical component. What is the inclination at the place ?

(a) $\tan^{-1}(1/1{\cdot}5)$

(b) $\sin^{-1}(1/1{\cdot}5)$

(c) $\cos^{-1}(1/1{\cdot}5)$

(d) $\tan^{-1}(1{\cdot}5)$

9. International Geomagnetic Reference Field (IGRF) correction removes :

(a) Effect of Earth's dipolar field only

(b) Effect of Earth's non-dipolar field only

(c) Effect of both, Earth's dipolar and non-dipolar fields

(d) Diurnal variations

10. Which one of the following is the correct geomagnetic anomaly order across the Pacific-Antarctica ridge, starting from its ridge axis, as suggested by Vine-Matthews-Morley ?

(a) Brunhes-Matuyama-Gilbert-Gauss

(b) Brunhes-Gilbert-Gauss-Matuyama

(c) Brunhes-Gauss-Matuyama-Gilbert

(d) Brunhes-Matuyama-Gauss-Gilbert

11. Consider the following statements regarding passage of seismic waves during earthquakes :

Statement 1 :

Rocks and minerals in the Earth react differently to stresses that may be brief and sudden.

Statement 2 :

The stress response of rocks and minerals at depth in the Earth is affected by temperature, pressure and time of burial that exists at that depth.

Which of the statement(s) given above is/are correct ?

(a) 1 only

(b) Both 1 and 2

(c) 2 only

(d) Neither 1 nor 2

12. The ground motion during an earthquake is recorded on a three-component seismometer. Which one of the following components will show the maximum amplitude of Rayleigh wave ?

(a) Vertical (up-down) only

(b) East-West only

(c) North-South

(d) East-West and Vertical (up-down) both

13. Consider the following statements regarding the phase and group velocities of surface waves :

1. For Earth, the phase velocity of both Love and Rayleigh waves generally increases with period.

2. Love waves are intrinsically dispersive even when the surface layer and underlying half-space are uniform.

3. Rayleigh waves over a uniform half-space are dispersive.

Which of the statements given above are correct ?

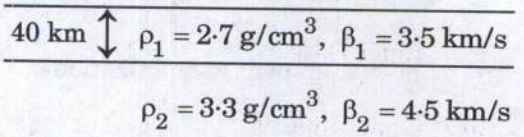
(a) 1 and 2 only

(b) 1 and 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

14. Consider a simple layer over a half-space model for the continental crust as shown in the diagram :



(where ρ = density, β = shear wave velocity; arctan 2·58 $\approx$ 1·20 rad)

What will be the period of fundamental Love wave travelling with a phase velocity of 3·8 km/s ?

(a) 12·2 s

(b) 23·4 s

(c) 38·1 s

(d) 42·6 s

15. If the upper and lower mantle are convecting separately, what will happen to the temperature structure of the Earth's mantle compared to the whole mantle convection ?

(a) Increase in temperature of lower mantle only

(b) Increase in temperature of upper mantle only

(c) Increase in temperature of both upper mantle and lower mantle

(d) Decrease in temperature of lower mantle only

16. Which one of the following layers of the Earth has almost the same density as the average density of the Earth ?

(a) Inner Core

(b) Upper Mantle

(c) Lower Mantle

(d) Outer Core

17. What will be the value of Reynolds number for mantle layer with density, large scale of the flow, viscosity and velocity of flow as 5000 kg/m^3, 2900 km, $1{\cdot}5 \times 10^{21}$ Pa.s and 5 cm/year, respectively ?

(a) $1{\cdot}5 \times 10^{5}$

(b) $1{\cdot}5 \times 10^{-10}$

(c) $1{\cdot}5 \times 10^{-2}$

(d) $1{\cdot}5 \times 10^{-20}$

18. What portion of the upper mantle appears to attenuate seismic waves the most ?

(a) 40 – 60 km

(b) 80 – 220 km

(c) 240 – 410 km

(d) 410 – 660 km

19. Which one of the following statements regarding the response function of an inertial seismometer is correct ?

(a) It includes the effects of various forces that act on the suspended mass.

(b) It is independent of the forces acting on the suspended mass.

(c) It includes the effects of spring forces on the suspended mass only.

(d) It includes the effects of viscous damping force on suspended mass only.

20. The Wadati-Benioff zone is related to :

(a) Seismicity at subduction zone

(b) Seismicity at conservative plate boundary

(c) Seismicity at mid-oceanic ridge

(d) Seismicity in the plate interiors

21. Consider the following statements regarding the earthquake seismology :

1. Long-period seismometers record the signals with periods in the range of 0·1 to 1·0 sec.
2. PKiKP is a P-wave that travels through mantle, outer core and inner core.
3. In the earthquake frequency (N), magnitude (M_S) relationship given by $\log N = a - bM_S$, the value of 'b' varies between 8 and 9 from region to region.

Which of the statements given above are correct ?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

22. The special class of strike-slip fault that joins active segments of the ridge is known as :

(a) Normal fault

(b) Reverse fault

(c) Transform fault

(d) Listric fault

23. Which one of the following earthquake magnitude scales considers the wave amplitude around 0·8 sec and is highly useful in engineering seismology ?

(a) Surface-wave magnitude scale

(b) Body-wave magnitude scale

(c) Local magnitude scale

(d) Moment magnitude scale

24. If $x = a \sin\theta \cos\phi$ and $y = a \sin\theta \sin\phi$, then the value of $a^2 - x^2 - y^2$ is :

(a) $a^2 \sin^2\theta$

(b) $a^2 \sin^2\phi$

(c) $a^2 \cos^2\theta$

(d) $a^2 \cos^2\phi$

25. What is the value of $\phi(1, 2, 3)$ for a function defined as $\phi(x, y, z) = 3x^2z^2 - xy^3 - 15$?

(a) 2

(b) 4

(c) 8

(d) 12

26. What is the value of $\int_1^2 \mathbf{F}(x)\,dx$, if $\mathbf{F}(x) = 3\hat{i} + \frac{4}{x^2}\hat{j} + 2x\hat{k}$?

(a) $3\hat{i} - 2\hat{j} + 4\hat{k}$

(b) $3\hat{i} - 2\hat{j} + 3\hat{k}$

(c) $3\hat{i} + 2\hat{j} + 3\hat{k}$

(d) $3\hat{i} + 2\hat{j} + 8\hat{k}$

27. Which one of the following relations represents Stokes' theorem ?

(where all symbols have their usual meaning)

(a) $\iiint \vec{\nabla} \cdot \vec{A}\ dV = \oiint_S \vec{A} \cdot d\vec{S}$

(b) $\int_C \vec{A} \cdot d\vec{S} = \iint (\vec{\nabla} \times \vec{A}) \cdot d\vec{S}$

(c) $\oint_C \vec{A} \cdot d\vec{S} = \iiint \vec{\nabla} \cdot \vec{A}\, dV$

(d) $\oint_C \vec{A} \cdot d\vec{r} = \iint_S (\vec{\nabla} \times \vec{A}) \cdot d\vec{S}$

28. The inverse of the matrix $A = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$ is :

(a) $\frac{1}{10}\begin{bmatrix} 3 & 1 \\ 2 & 4 \end{bmatrix}$

(b) $\frac{1}{10}\begin{bmatrix} 3 & -1 \\ -2 & 4 \end{bmatrix}$

(c) $\frac{1}{10}\begin{bmatrix} 3 & 1 \\ -2 & 4 \end{bmatrix}$

(d) $\frac{1}{10}\begin{bmatrix} 3 & -1 \\ 2 & 4 \end{bmatrix}$

29. The eigenvalues of the matrix $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ are :

(a) 1, 2

(b) 0, 2

(c) 2, 1

(d) 0, 1

30. The acceleration due to gravity at the Earth's surface is :

(where G is the gravitational constant, M_E is the mass of the Earth and R_E is the radius of the Earth)

(a) $\frac{GM_E}{R_E}$

(b) $\frac{GM_E}{R_E^2}$

(c) $\frac{GM_E}{R_E^3}$

(d) $\frac{R_E^2}{GM_E}$

31. The time period of a satellite moving in a circular orbit of radius r around the Earth is proportional to :

(a) $r^{1/2}$

(b) $r^{3/2}$

(c) $r^{-3/2}$

(d) $r^{-1/2}$

32. The spin of the graviton is :

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

(b) 0

(c) 1

(d) 2

33. Which one of the following statements regarding work done by a conservative force is ***not*** correct ?

(a) It is given by the difference between the initial and final values of a potential-energy function.

(b) It is not reversible.

(c) It is independent of the path of the object and depends only on starting and ending points.

(d) The total work done is zero for a closed path.

34. The moment of inertia of a rotating body is decreased to $\frac{1}{4}$ times and its angular velocity is increased to 4 times; then kinetic energy of the rotating body will :

(a) be decreased by a factor of $\frac{1}{4}$

(b) be increased by a factor of 4

(c) not change

(d) be increased by a factor of 2

35. A rigid body rotation in (X, Y, Z) coordinates is given as :

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} \rightarrow \begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

then :

(a) Z-axis is the rotation axis and the angle of rotation is $\frac{\pi}{2}$

(b) Y-axis is the rotation axis and the angle of rotation is π

(c) Z-axis is the rotation axis and the angle of rotation is π

(d) Y-axis is the rotation axis and the angle of rotation is $\frac{\pi}{2}$

36. The correct expression for time dilation is :
(where γ is the Lorentz factor relating the two frames and Δt_0 is the proper time interval between two events measured in the rest frame of the clock)

(a) $\gamma^2 \Delta t_0$

(b) $\gamma \Delta t_0$

(c) $\Delta t / \gamma$

(d) $\Delta t_0 / \gamma^2$

37. What is the first-order correction to the non-relativistic kinetic energy for the relativistic energy of a particle given as $K = (\gamma - 1) mc^2$?
(here γ is the Lorentz factor, the particle has mass 'm' and speed 'v', and 'c' is the speed of light)

(a) $\frac{3}{4}\frac{mv^2}{c^2}$

(b) $\frac{3}{8}\frac{mv^2}{c^2}$

(c) $\frac{3}{4}\frac{mv^4}{c^2}$

(d) $\frac{3}{8}\frac{mv^4}{c^2}$

38. What is the speed of an electron accelerated from rest due to potential increase of 5·11 MV of electric field ?
(where 'c' is the speed of light)

(a) 0·096 c

(b) 0·816 c

(c) 0·996 c

(d) 0·086 c

39. σ^x and σ^y are standard errors in the measurement of x and y respectively, and both x and y are independently measured quantities. If $\omega = x - y$, then standard error in ω is :

(a) $\sqrt{(\sigma^x)^2 - (\sigma^y)^2}$

(b) $\sqrt{(\sigma^x)^2 + (\sigma^y)^2}$

(c) $\sqrt{1 + (\sigma^y)^2}$

(d) $\sqrt{(\sigma^x)^2 - 1}$

40. Consider the following set of measurements :

[7·2, 7·0, 7·1]

The variance of all the measurements is :

(a) 0·1

(b) 0·2

(c) 0·01

(d) 0·02

41. The solution of the differential equation $\frac{\partial^2 y}{\partial x^2} = y$ which passes through the origin (0, 0) and the point $(ln\ 2, \frac{3}{4})$ is :

(a) $\frac{e^x + e^{-x}}{2}$

(b) $\frac{e^{ix} - e^{-ix}}{2}$

(c) $\frac{e^x - e^{-x}}{2}$

(d) $\frac{e^{ix} - e^{-ix}}{2}$

42. Consider the following differential equation :

$$\frac{\partial^2 y}{\partial x^2} - 6\frac{\partial y}{\partial x} + 9y = 0$$

The solution of the above equation can be written as :

(a) $(Ax + B)\, e^{3x}$

(b) $(Ax + B)\, e^{-3x}$

(c) $Ae^{i3x} + Be^{-3ix}$

(d) $Ae^{3x} + Be^{-3x}$

43. The solution of the partial differential equation $x\frac{\partial u}{\partial x} + xy = u$ satisfying u = 2y on the line x = 1 may be worked out to yield :

(a) xy (2 + *ln* x)

(b) xy (2 – *ln* x)

(c) xy (2 + *ln* y)

(d) xy (2 – *ln* y)

44. Which one of the following statements is correct for the wave equation $\frac{\partial^2 u}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} = 0$?

(a) It is an elliptic equation.

(b) It is a parabolic equation.

(c) The appropriate boundary conditions are Cauchy conditions on an open boundary.

(d) The appropriate boundary conditions are Dirichlet or Neumann conditions on a closed boundary.

45. Which one of the following equations is the correct representation of the heat equation ?
(where symbols have their usual meaning)

(a) $\nabla^2 u = 0$

(b) $\nabla^2 u = \frac{1}{\alpha^2}\frac{\partial u}{\partial t}$

(c) $\nabla^2 u = \frac{1}{v^2}\frac{\partial^2 u}{\partial t^2}$

(d) $\frac{-\hbar^2}{2m}\nabla^2\phi + V\phi = +i\hbar\frac{\partial}{\partial t}\phi$

46. Given $y_1 = a \sin z^3$ and $y_2 = b \cos z^3$, the value of the Wronskian $W(y_1, y_2)$ is :

(a) $-abz^2$

(b) abz^2

(c) $-3abz^2$

(d) $3abz^2$

47. Let $f(x) = x \sin x + \cos x$, then the iteration formula by the Newton-Raphson method is :

(a) $x_{n+1} = x_n + \dfrac{x_n \sin x_n + \cos x_n}{x_n \cos x_n}$

(b) $x_{n+1} = x_n - \dfrac{x_n \sin x_n + \cos x_n}{x_n \cos x_n}$

(c) $x_{n+1} = x_n + \dfrac{x_n \sin x_n - \cos x_n}{x_n \sin x_n}$

(d) $x_{n+1} = x_n - \dfrac{x_n \sin x_n + \cos x_n}{x_n \sin x_n}$

48. Use Simpson's rule, given by the formula $I = \dfrac{1}{6}[y_0 + 4y_1 + y_2]$ in the usual notation, to evaluate $I = \displaystyle\int_0^1 \frac{dx}{1+x}$. Then I equals :

(a) 0·6970

(b) 0·7083

(c) 0·6945

(d) 0·6983

49. The Taylor series method is applied to solve the equation $\dfrac{dy}{dx} = x^2 + y^2$ under the condition $y(x) = 1$ when $x = 0$. The first few terms in the series are :

(a) $1 + x + x^2 + \dfrac{8}{3!}x^3$

(b) $1 + x^2 + \dfrac{8}{3!}x^4$

(c) $1 - x + x^2 + \dfrac{8}{3!}x^3$

(d) $1 - x^2 - \dfrac{8}{3!}x^4$

50. Which one of the following statements regarding equipotential surfaces is correct ?

(a) The electric field lines and equipotential surfaces are always in the same direction.

(b) The electric field lines and equipotential surfaces are always mutually perpendicular.

(c) The angles between the electric field lines and equipotential surfaces depend on the potential on the surface.

(d) The directions of electric field lines and equipotential surfaces are unrelated.

51. Suppose that at a certain location on the globe, the Earth's magnetic field of 40 μT is horizontal and directed northward. Let there be a long, straight, horizontal wire, carrying a uniform current I. If the Earth's magnetic field be cancelled by the magnetic field due to the wire at a distance 8 cm above it, then what would be the magnitude of the current I in ampere ?

(The free space permeability $\mu_0 = 4\pi \times 10^{-7}$ H/m)

(a) 4

(b) 2

(c) 24

(d) 16

52. Consider a particle of charge $q = -2 \times 10^{-9}$ C placed in an electric field produced due to a charged cloud near the Earth's surface. If the electrostatic force acted on the particle is downward (i.e. towards the centre of the Earth), and of magnitude 3×10^{-6} N, then the magnitude and direction of the electric field $\vec{E}$ are given by :

(a) 15 N/C, upward

(b) 1500 N/C, upward

(c) 15 N/C, downward

(d) 1500 N/C, downward

53. Consider a charge Q on a tiny sphere. Let a portion of it, say q, be transferred to a nearby tiny sphere. If both the spheres are treated as particles, then the electrostatic force of repulsion between them would be maximum for :

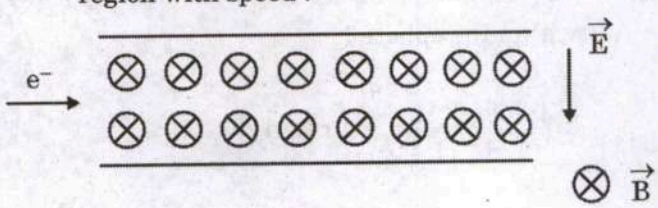
(a) $q = Q/4$

(b) $q = Q/8$

(c) $q = Q/2$

(d) $q = 3Q/4$

54. An electron is allowed to transit through a region of space in which there is an electric field of magnitude 1·5 kV/m and a magnetic field 0·25 T is applied as shown in the figure. If the electron leaves the region without being deflected, then it would have entered the region with speed :



(a) 1·5 km/s

(b) 3·5 km/s

(c) 4·5 km/s

(d) 6·0 km/s

55. Consider a particle of mass 100 mg and charge -5×10^{-8}C moving in the Earth's gravitational field. Let the particle's initial velocity be horizontal, due north, and of magnitude 40 km/s. A horizontal, eastward magnetic field will keep the particle moving (under the influence of gravity) in the same horizontal, northward direction, if the magnitude of such a field has the minimum value :
(taking the acceleration due to gravity $g = 9{\cdot}8\ m/s^2$)

(a) 0·98 T

(b) 0·49 T

(c) 1·96 T

(d) 1·47 T

56. A uniformly charged solid sphere, of radius R and total charge Q, is centered at the origin and spinning at a constant angular velocity $\vec{\omega}$ about the z-axis. The magnitude of the curl of the magnetic field $\vec{B}$ at a point (r, θ, ϕ) within the sphere is :

(a) $\frac{\mu_0}{4\pi}\frac{Q}{R^4}|\vec{\omega}|\, r^2 \sin 2\theta$

(b) $\frac{\mu_0}{4\pi}\frac{3Q}{R^3}|\vec{\omega}|\, r \sin\theta$

(c) $\frac{\mu_0}{4\pi}\frac{Q}{R^4}|\vec{\omega}|\, r^2 \sin\theta$

(d) $\frac{\mu_0}{4\pi}\frac{3Q}{R^3}|\vec{\omega}|\, r \sin 2\theta$

57. Consider the circular acceleration of singly charged ions (of mass number A) that are projected perpendicularly into a magnetic field of magnitude B. When the ions are accelerated to a kinetic energy E_k, the radius of their circular orbit, assuming non-relativistic motion, can be expressed in terms of the charge and mass of a proton, e and m_p, as :

(a) $r = \frac{E_k\sqrt{A\, m_p}}{e\, B}$

(b) $r = \frac{\sqrt{A E_k\, m_p}}{2e\, B}$

(c) $r = \frac{\sqrt{2A E_k\, m_p}}{e\, B}$

(d) $r = \frac{E_k\sqrt{2\, A\, m_p}}{e\, B}$

58. Consider an electric field in a certain region of the Earth's atmosphere. Let the electric field be directed vertically down, and have magnitude 100 N/C at an altitude 200 m and 60 N/C at an altitude 300 m. In terms of the free space permittivity ε_0, the net amount of charge contained in a cube of sides 100 m, and with horizontal faces at altitudes of 200 m and 300 m, would be :

(a) $q = 2\times10^4\,\varepsilon_0$

(b) $q = 4\times10^5\,\varepsilon_0$

(c) $q = 2\times10^6\,\varepsilon_0$

(d) $q = 6\times10^5\,\varepsilon_0$

59. A long, cylindrical wire carries a current I distributed uniformly over its cross-sectional area A. Let B_0 be the magnitude of the magnetic field strength, due to the current I, at the surface of the wire. The magnetic field strength is half of B_0 (in magnitude) at a distance (from the axis of the wire) :

(a) $\sqrt{2A/\pi}$

(b) $\sqrt{2A}/\pi$

(c) $2\sqrt{A/\pi}$

(d) $2\sqrt{2A/\pi}$

60. Consider two metal plates, each having an area A, parallel to the xy plane and separated by a distance d along z. If the upper plate is held at a fixed potential V_0 and the lower plate $(z = 0)$ is grounded, then the potential distribution along the z-direction is given by :

(a) $V = V_0 (2xy + z)/d$

(b) $V = 2V_0 z/d$

(c) $V = V_0 (xy + 2z)/d$

(d) $V = V_0 z/d$

61. The electric flux through a certain area of a dielectric varies with time as $\Phi \propto t^{1/3}$. If at a time t = 3 sec, the displacement current through that area is 24 A, then its value is 6 A at a time :

(a) 15 sec

(b) 24 sec

(c) 1 sec

(d) 6 sec

62. Consider a short current element $\vec{dl} = b\hat{y}$, and a point P located at $\vec{r} = b(\hat{x} + \sqrt{3}\,\hat{z})$ where b is a constant, and $\hat{x}$, $\hat{y}$, $\hat{z}$ denote the unit vectors along the x, y, z directions, respectively. The magnetic field at P, due to the current I carried by the element $\vec{dl}$ along the y direction, can be expressed in terms of the free space permeability μ_0 as :

(a) $\frac{\mu_0 I}{16\pi b}(\hat{x} + \sqrt{3}\,\hat{z})$

(b) $\frac{\mu_0 I}{32\pi b}(\sqrt{3}\,\hat{x} + \hat{z})$

(c) $\frac{\mu_0 I}{16\pi b}(\hat{x} - \sqrt{3}\,\hat{z})$

(d) $\frac{\mu_0 I}{32\pi b}(\sqrt{3}\,\hat{x} - \hat{z})$

63. An electrical circuit is placed in a magnetic field. An emf can be induced in the circuit by changing :

(a) The magnetic field only

(b) The area of cross-section only

(c) The electric current in the given electric circuit only

(d) The magnetic field or the area of cross-section or the angle between the magnetic field and the plane of the circuit

64. Suppose that magnetic charges q_{m1}, q_{m2}, ... exist, and there is a Coulomb's law for such charges, given by $\vec{F} = \frac{\mu_0}{4\pi} \frac{q_{m1}\, q_{m2}}{r^2} \hat{r}$, then, for a given magnetic charge q_m moving with a velocity $\vec{v}$, through electric and magnetic fields, $\vec{E}$ and $\vec{B}$ respectively the force law using the principle of electromagnetic duality can correspondingly be expressed as :

(a) $\vec{F} = q_m(\vec{B} + \vec{v} \times \vec{E}/c^2)$

(b) $\vec{F} = q_m \vec{v} \times \vec{E}/c^2$

(c) $\vec{F} = q_m(\vec{B} - \vec{v} \times \vec{E}/c^2)$

(d) $\vec{F} = q_m \vec{B}$

65. If the peak magnetic field in a plane electromagnetic wave is 2×10^{-4} T, then the average energy density corresponding to the electromagnetic wave is :

(a) $\frac{1}{20\pi}$ J/m^3

(b) $\frac{20}{\pi}$ J/m^3

(c) $\frac{1}{2\pi}$ J/m^3

(d) $\frac{2}{\pi}$ J/m^3

66. A source of sinusoidal electromagnetic waves radiates in all directions. If at a distance 15 m from this source, the amplitude of the electric field of the wave is 2 N/C, then at a distance 30 cm from the source, the electric field amplitude would be :

(a) 60 N/C

(b) 0·1 N/C

(c) 100 N/C

(d) 6 N/C

67. The total intensity of electromagnetic radiation from a star, as measured by a space probe at a distance 2×10^{10} m away from it, is 5000 W/m^2. If the star radiates uniformly in all directions, then its total average power output is :

(a) $8\pi \times 10^{24}$ W

(b) $2\pi \times 10^{24}$ W

(c) $8\pi \times 10^{22}$ W

(d) $2\pi \times 10^{25}$ W

68. Which one of the following factors is responsible for different density values measured during *in-situ* and laboratory conditions ?

(a) Surrounding rocks density

(b) Porosity

(c) Mineral constituents

(d) Measurement principle

69. What is the factor by which the true resistivity of 25% water saturated formation increases in comparison to fully water saturated formation according to Archie's equation ? (Given saturation exponent = 2)

(a) 2

(b) 8

(c) 16

(d) 0·062

70. In an aeromagnetic survey at a flight altitude of 1000 m above sea-level, the maximum total field anomaly over an ore body measured at centre was 160 nT. In a repeated measurement at 2500 m altitude, the maximum amplitude of the anomaly was 20 nT. What will be the depth of the ore body below sea-level assuming a monopole sphere source for the ore body ?

(a) 375 m

(b) 500 m

(c) 625 m

(d) 750 m

71. A plane electromagnetic wave of wavelength 2 μm is being used to infer subsurface properties across a geological region. The land surface in the region consists of soil A and soil B with electrical conductivities as $10^{-3}\ \Omega^{-1}\ m^{-1}$ and $10^{-1}\ \Omega^{-1}\ m^{-1}$, respectively. Which one of the following statements regarding the wave penetration in soil A and soil B is correct ?

(a) The wave penetrates soil A up to 10 times greater depth than soil B.

(b) The wave penetrates soil B up to 10 times greater depth than soil A.

(c) The wave penetrates soil A up to 100 times greater depth than soil B.

(d) The wave penetrates soil B up to 100 times greater depth than soil A.

72. Consider the following statements regarding remanent magnetization :

1. Thermoremanent magnetization results when magnetic material is cooled above the Curie point in the presence of external field.
2. Lightning strikes produce isothermal remanent magnetization over a very small area.

Which of the statement(s) given above is/are correct ?

(a) 1 and 2 both

(b) 1 only

(c) 2 only

(d) Neither 1 nor 2

73. Consider the following statements regarding geoelectrical methods :

1. Dipole-dipole array is least influenced by inductive coupling.
2. In Schlumberger gradient profiles obtained over faults, dikes/veins show gentler gradient than the Wenner profiling.
3. For resolution of horizontally layered structures, the Schlumberger and Wenner arrays are preferred over the other arrays.

Which of the statement(s) given above is/are ***not*** correct ?

(a) 1 and 3

(b) 1 only

(c) 2 only

(d) 2 and 3

74. Match List-I with List-II and select the correct answer using the code given below the lists :

List-I (Frequency range)	*List-II (Geophysical method)*
P. 10^{-4} Hz to 1 Hz	1. VLF
Q. 400 Hz to 2000 Hz	2. GPR
R. 20 kHz to 25 kHz	3. MT
S. 25 MHz to 1·2 GHz	4. Slingram

Code :

	P	Q	R	S
(a)	2	1	4	3
(b)	3	1	4	2
(c)	2	4	1	3
(d)	3	4	1	2

75. Let sphere 'A' of mass excess (M_A) in metric tons lying at a depth Z (km) produce a maximum anomaly of g_A (mGal). Suppose sphere 'A' is now replaced by another sphere 'B' at the same depth with its mass excess as 0·5 times M_A (metric tons) and produces a maximum anomaly of g_B (mGal). Which one of the following is the correct relation between g_A and g_B ?

(a) $g_A = 0{\cdot}5\ g_B$

(b) $g_A = 2{\cdot}0\ g_B$

(c) $g_B = 6{\cdot}5\ g_A$

(d) $g_B = 2{\cdot}0\ g_A$

76. What will be the ratio of critical distance (X_{crit}) to the crossover distance (X_c) for a model having a layer of velocity V_1 lying above another layer of velocity V_2 ($>V_1$) ?

(a) $\frac{V_1+V_2}{V_1}$

(b) $\frac{V_1}{V_2-V_1}$

(c) $\frac{V_1}{V_1+V_2}$

(d) $\frac{V_2}{V_1+V_2}$

77. What is the P-wave velocity of a fully-fluid saturated formation having 25% porosity, if P-wave velocity in rock matrix and saturating fluid is 3000 ms^{-1} and 1500 ms^{-1} respectively ?

(a) 2700 ms^{-1}

(b) 2400 ms^{-1}

(c) 2100 ms^{-1}

(d) 1800 ms^{-1}

78. Consider the following statements regarding the shallow reflection technique :

1. Smaller energy sources with longer detector spreads are used in the survey.
2. Mapping of low velocity channels is possible.
3. Resolve the depositional features within the overburden material.
4. Appropriate for surveying when the surface layer is clay or silt with shallow water table.

Which of the statement(s) given above is/are correct ?

(a) 1 and 2 only

(b) 2, 3 and 4 only

(c) 1 only

(d) 1, 2, 3 and 4

79. If 'd' is the depth of shot below the reflector producing the ghost in seismic survey, what is the effective path difference between the direct wave and ghost wave ?

(a) $\frac{\lambda}{2}+d$

(b) $\lambda+\frac{d}{2}$

(c) $\lambda+d$

(d) $\frac{\lambda}{2}+2d$

80. The minimum frequency at which a signal comprising of 30 Hz, 50 Hz and 70 Hz frequencies should be sampled to avoid aliasing is :

(a) 25 Hz

(b) 35 Hz

(c) 70 Hz

(d) 140 Hz

81. The band-limited signal is uniquely represented by its samples. In practice, however, narrow, large amplitude pulses, which approximate impulses, are also relatively difficult to generate and transmit. What is the convenient form of sampled signal generated ?

(a) Zero-order hold

(b) First-order hold

(c) Ideal low-pass filter

(d) Cascade combination

82. A wave filtered at 200 Hz is aliased due to the sampling process. The sampling rate of the signal is 350 Hz. What is the output frequency ?

(a) 175 Hz

(b) 150 Hz

(c) 125 Hz

(d) 100 Hz

83. Consider the following statements regarding the Fourier Transformation (FT) of a time series 'g(t)' :

1. FT converts g(t) into its equivalent amplitude and phase spectra.
2. FT converts g(t) into a complex function of frequency.
3. FT converts g(t) into its equivalent phase spectra only.
4. FT converts g(t) into a real function of frequency.

Which of the statements given above are correct ?

(a) 1 and 3

(b) 1 and 2

(c) 2 and 3

(d) 3 and 4

84. Consider the following statements regarding the scaling of a signal in time and frequency domains :

1. Linear expansion in time domain gives rise to linear contraction in frequency domain.
2. Linear contraction in time domain gives rise to linear expansion in frequency domain.
3. Linear expansion in time domain gives rise to linear expansion in frequency domain.

Which of the statement(s) given above is/are correct ?

(a) 1 and 2

(b) 2 and 3

(c) 3 only

(d) 1 only

85. The Fourier series expansion for $\cos^2(x) - 4\sin^4(x) - 3\cos^3(2x)$ contains :

(a) Sine terms only

(b) Constant terms only

(c) Both non-zero cosine and sine terms

(d) Cosine terms only

86. Consider a two-dimensional function $f(x_1, x_2)$ in the spatial domain and $F(\varepsilon_1, \varepsilon_2)$ be its Fourier transform. Identify the correct relation between $f(x_1, x_2)$ and $F(\varepsilon_1, \varepsilon_2)$ if x_1 and x_2 are scaled independently by a factor of a_1 and a_2, respectively :

(a) $f(a_1x_1, a_2x_2) \leftrightarrow a_1a_2 F\left(\frac{\varepsilon_1}{a_1}, \frac{\varepsilon_2}{a_2}\right)$

(b) $f(a_1x_1, a_2x_2) \leftrightarrow \frac{1}{a_1a_2} F\left(\frac{\varepsilon_1}{a_1}, \frac{\varepsilon_2}{a_2}\right)$

(c) $f(a_1x_1, a_2x_2) \leftrightarrow a_1a_2 F(a_1\varepsilon_1, a_2\varepsilon_2)$

(d) $f(a_1x_1, a_2x_2) \leftrightarrow \frac{1}{a_1a_2} F(a_1\varepsilon_1, a_2\varepsilon_2)$

87. The axis of complex plane at which the Laplace and Fourier transforms converge is :

(a) Real axis

(b) Imaginary axis

(c) Positive side of real axis only

(d) Positive side of imaginary axis only

88. Cross-correlate the wavelet g[n] = {2, 5, – 2, 1} with another wavelet f]n]= {6, – 1, – 1}. For what shift are these functions being mostly alike ?

(a) 0

(b) – 1

(c) + 1

(d) – 2

89. The value of $\sum_{n=0}^{\infty} \delta(n+1)\, 4^n$ is :

(where, $\delta(n)$ is delta function)

(a) 4

(b) – 1

(c) 1

(d) 0

90. The near field displacement record of an earthquake was found to be closely approximated as the function

$$f(t) = \begin{cases} 0, & t \le t_0 \\ 1, & t > t_0 \end{cases}$$

What would be the velocity record look like ?
(δ represents a Dirac-Delta function)

(a) 0 (Zero)

(b) $\delta(t - t_0)$

(c) 1

(d) $\delta(t)$

91. In an eight-bit remote sensing image, the digital number (DN) value lies between 64 and 128. After doing linear contrast enhancement of the whole data, what will be the value of DN = 98 after transformation ?

(a) 34

(b) 64

(c) 135

(d) 168

92. Ratio of radiating capability or exitance of a surface to that of a black body is defined as :

(a) Emissivity

(b) Reflectivity

(c) Reflectance

(d) Radiance

93. Which one of the following parameters does ***not*** govern the spatial resolution of an optical remote sensing image ?

(a) Modulation Transfer Function (MTF)

(b) Signal to Noise Ratio (SNR)

(c) Object Contrast

(d) Object Temperature

94. Which colour of the visible light has the highest sensitivity for the human eye ?

(a) Violet

(b) Yellow-Green

(c) Blue

(d) Orange-Red

95. Sunlight strikes the surface of the Earth with an average intensity of 1400 W/m^2. The maximum value of the electric field associated with electromagnetic radiations is approximately :

(a) 1060 V/m

(b) 1400 V/m

(c) 2800 V/m

(d) 700 V/m

96. The radiant emittance of a blackbody at a temperature of 400 K is :

(a) 1452×10^0 Watts/m^2

(b) 1452×10^1 Watts/m^2

(c) 1452×10^2 Watts/m^2

(d) 1452×10^3 Watts/m^2

97. The entropy for a black body radiation is :

(where T = temperature, V = volume and 'a' is the constant which appears in the expression for radiation energy density u : $u = aT^4$)

(a) $\frac{4}{3} aT^3V$

(b) $\frac{4}{3} aT^5V$

(c) $\frac{2}{3} aT^3V$

(d) $\frac{2}{3} aT^5V$

98. What is the temperature at which the Kelvin and Fahrenheit scales coincide ?

(a) 274·25

(b) 574·25

(c) 374·25

(d) – 40

99. A Carnot engine absorbs 200 J of heat from a reservoir at the temperature of 273·17°C. What is the work done by the engine, if it rejects heat to the reservoir at a temperature of triple point of water ?

(a) 300 J

(b) 400 J

(c) 150 J

(d) 100 J

100. Which one of the following statements regarding molar heat capacities for all ideal gases is true ?

(where T is temperature and other symbols have their usual meaning)

(a) C_v is not a function of T.

(b) C_P is a function of T only and is less than C_v.

(c) $C_P - C_v$ is not a function of T.

(d) The ratio C_P / C_v is not a function of T and is less than 1.

101. The electric quadrupole moment for a spherical nucleus is :

(a) Positive

(b) Negative

(c) Zero

(d) Dependent on the atomic number of the nucleus

102. Which one among the following best describes nuclear force ?

(a) A strong long-range force between two nucleons which depends on their electric charges

(b) A weak short-range force between two nucleons which depends on their electric charges

(c) A strong short-range force which is responsible for the attraction between a proton and a neutron

(d) A weak long-range force which is responsible for the attraction between a proton and a neutron

103. Which one of the following set of charges can be possessed by quarks present in a nucleon ?

(a) – 2/3 and – 1/3 times the electron charge

(b) + 2/3 and – 1/3 times the electron charge

(c) – 2/3 and + 1/3 times the electron charge

(d) + 2/3 and + 1/3 times the electron charge

104. The binding energy is often expressed in mass units. One atomic mass unit is equivalent to : (where c is the speed of light in vacuum)

(a) 931·494 MeV/c^2

(b) 93·1494 MeV/c^2

(c) 9·31494 MeV/c^2

(d) 9314·94 MeV/c^2

105. Which of the following moderator(s) can be used in fission reactors fuelled by natural uranium ?

(a) Beryllium

(b) Boron

(c) Cadmium

(d) ^{12}C in the form of graphite or D_2O

106. Among the stable nuclei, the ratio of neutron number (N) to proton number (Z) increases with atomic mass (A) because of :

(a) Large Coulombic repulsion among protons as Z increases.

(b) Increase in pairing effect between neutrons and protons.

(c) Magic number of neutrons, provides more stability as A increases.

(d) Large surface energy of the nucleus as Z increases.

107. Decay of $^{137}_{55}Cs$ radioactive source is an example of :

(a) Alpha decay

(b) Beta plus decay

(c) Beta minus decay

(d) Neutron decay

108. When gamma-rays are scattered by an electron at rest then :

(a) The wavelength of the scattered gamma-ray is less than that of the incident ray and it does not depend on the angle of scattering.

(b) The wavelength of the scattered gamma-ray is greater than that of the incident ray and it depends on the angle of scattering.

(c) The wavelength of the scattered gamma-ray is less than that of the incident ray and it depends on the angle of scattering.

(d) The wavelength of the scattered gamma-ray is greater than that of the incident ray and it does not depend on the angle of scattering.

109. The probability of photoelectric absorption for gamma rays incident on a medium depends on :

(a) Energy of the gamma rays and atomic mass of the absorber medium

(b) Energy of the gamma rays and atomic number of the absorber medium

(c) Atomic mass of the absorber medium but not on the energy of the gamma rays

(d) Atomic number of the absorber medium but not on the energy of the gamma rays

110. Which one of the following radioactive minerals has Thorium (Th) radioactivity ?

(a) Alunite

(b) Carnotite

(c) Monazite

(d) Muscovite

111. The daughter nucleus produced after beta-plus decay of $^{107}_{48}Cd$ is :

(a) $^{107}_{49}In$

(b) $^{108}_{48}Cd$

(c) $^{107}_{47}Ag$

(d) $^{107}_{46}Pd$

112. $^{238}_{92}U$ ***cannot*** spontaneously emit a proton as :

(a) $^{238}_{92}U$ is not a radioactive element

(b) $^{238}_{92}U$ is a heavy element

(c) The proton is a stable particle

(d) The process has a negative Q value

113. In a typical gamma-ray detector, what processes occur for an incident high-energy photon ?

1. It undergoes Compton scattering a few times and may leave the detector before depositing all its energy.
2. It undergoes multiple Compton scattering, followed by photoelectric absorption and complete energy deposition.
3. It produces an $e^+ e^-$ pair, followed by positron annihilation, Compton scattering and photoelectric absorption and complete energy deposition.
4. It produces an $e^+ e^-$ pair, followed by positron annihilation, and one or both annihilation photons escape.

Select the correct answer using the code given below :

(a) 1 and 3 only

(b) 2 and 4 only

(c) 1, 3 and 4 only

(d) 1, 2, 3 and 4

114. Geiger-Müller counter is used to measure :

1. Energy of the incident radiation
2. Charge of the incident radiation
3. Number count of the incident radiation

Select the correct answer using the code given below :

(a) 1 and 2

(b) 2 and 3

(c) 1 only

(d) 3 only

115. The magnitude of spin angular momentum of the electron is :

(a) $\sqrt{\frac{1}{2}}\ \hbar$

(b) $\sqrt{\frac{1}{4}}\ \hbar$

(c) $\sqrt{\frac{3}{4}}\ \hbar$

(d) $\sqrt{\frac{4}{3}}\ \hbar$

116. In which one of the following situations will a proton and an alpha particle have the same de Broglie wavelength ?

(Assume the non-relativistic approximation holds)

(a) The velocity of the proton is four times the velocity of the alpha particle.

(b) The velocity of the alpha particle is four times the velocity of the proton.

(c) Both the particles move with the same velocity.

(d) Both the particles move with the same kinetic energy.

117. Consider a particle of mass 'm' enclosed in a box of length 'L' with impenetrable walls. The longest wavelength of the particle trapped in the box is :

(a) $\frac{L}{2}$

(b) 2L

(c) $\frac{L}{3}$

(d) $\frac{2L}{3}$

118. An excited atom de-excites through the emission of photon with a lifetime of 10^{-8} sec. The inherent uncertainty in the frequency of the photon is about :

(a) 10^{7} Hz

(b) 10^{-26} Hz

(c) 10^{11} Hz

(d) 10^{-19} Hz

119. Which one of the following radiations takes place in the visible region ?

(a) Lyman Series

(b) Paschen Series

(c) Pfund Series

(d) Balmer Series

120. According to Bohr Model, the potential energy (U_n) for an electron in n^{th} orbit is :

(a) $-\frac{me^4}{2\varepsilon_0^2 n^2 h^2}$

(b) $-\frac{me^4}{4\varepsilon_0^2 n^2 h^2}$

(c) $-\frac{2me^4}{\varepsilon_0^2 n^2 h^2}$

(d) $-\frac{4me^4}{\varepsilon_0^2 n^2 h^2}$

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