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UPSC Combined Geo-Scientist (Prelims)

Previous Year Paper

(Geo-Physics) Paper-II

2023

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COMBINED GEO-SCIENTIST (P) EXAM-2023

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T.B.C. : SDGH–T–GPH **Test Booklet Series**

Serial No. 1002177

TEST BOOKLET

A

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.
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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. Brittle deformation is the main mechanism in the tectonic processes. It involves

(a) the uppermost 5–10 km of the lithosphere

(b) the uppermost 10–20 km of the lithosphere

(c) the boundary between lithosphere and asthenosphere

(d) the upper layer of the asthenosphere

2. The branch of Geophysics which deals with the Earth's geometrical shape, orientation, mass distribution and their variations with time is known as

(a) Astrophysics

(b) Geomagnetic Studies

(c) Geodesy

(d) Seismology

3. Which of the following Kepler's laws of planetary motion is/are the result of conservation of angular momentum?

(a) Kepler's first law only

(b) Kepler's second law

(c) Kepler's third law only

(d) Kepler's first law and third law

4. Which one of the following pairs of planets does ***not*** have any natural satellites?

(a) Mercury and Venus

(b) Mars and Mercury

(c) Mercury and Saturn

(d) Uranus and Venus

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

List–I (Gravity correction)	*List–II (Phenomenon)*
A. Tidal correction	1. Accounts for the time-dependent mechanical changes in the gravimeter
B. Drift correction	2. Accounts for time-varying gravitational attraction of the Sun and the Moon
C. Free-air correction	3. Accounts for the speed and direction of moving vehicle containing gravimeter
D. Eötvös correction	4. Accounts for the elevation of the gravimeter station

Code :

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

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6. The ratio of the centrifugal to gravitational acceleration is maximum at the equator. What would be its value, if the radius of the Earth is r_E, rotational angular velocity is ω, mass is M and gravitational constant is G?

(a) $\frac{\omega^2 r_E^2}{M^2}$

(b) $\frac{G\omega^2}{Mr_E^2}$

(c) $\frac{r_E^3 \omega^2}{GM}$

(d) $\frac{GM}{\omega^2 r_E^2}$

7. The centre of revolution of the Earth-Moon pair lies

(a) within the Earth

(b) within the Moon

(c) at the centre of the Earth-Moon distance

(d) very close to the Earth but outside of it

8. Which one of the following rock types has the highest value of magnetic susceptibility?

(a) Granite

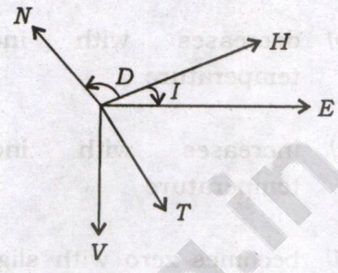
(b) Shale

(c) Gabbro

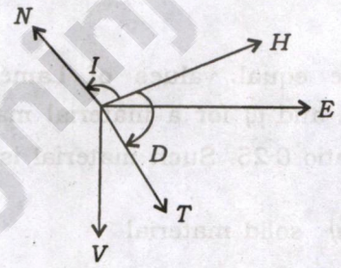
(d) Sandstone

9. Which one of the following correctly represents the geomagnetic declination (D), inclination (I) and total field direction (T)? (Here, N = geographic north and H = magnetic north)

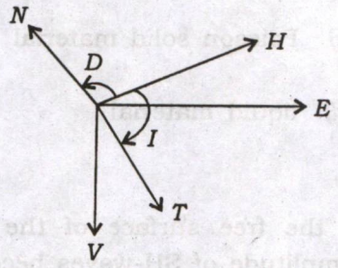
(a)



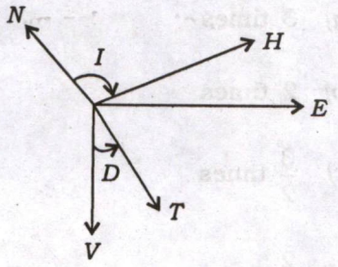
(b)



(c)



(d)



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10. The susceptibility of paramagnetic material

(a) remains unchanged with increasing temperature

(b) decreases with increase in temperature

(c) increases with increase in temperature

(d) becomes zero with slight increase in temperature

11. The equal values of Lamé constants (λ and μ) for a material make Poisson ratio 0·25. Such material is called

(a) solid material

(b) semi-solid material

(c) Poisson solid material

(d) liquid material

12. At the free surface of the Earth, the amplitude of SH-waves becomes

(a) 3 times

(b) 2 times

(c) $\frac{3}{2}$ times

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

13. The phase delay between the stress and strain of a material is 60 degree. The quality factor of the material will be

(a) 0·68

(b) 0·38

(c) 0·48

(d) 0·58

14. When the undeformed strike is used as a reference, the Piola-Kirchhoff stress tensor is

(a) not symmetric

(b) symmetric only

(c) orthogonal only

(d) both orthogonal and symmetric

15. Which one of the following seismic phases represents the P-wave conversion into S-wave during its passage through solid core?

(a) PKiKP

(b) PKJKP

(c) PKIKP

(d) PcS

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16. Consider the following statements regarding hotspot :

1. Hotspot is long-lasting centre of surface volcanism and locally high heat flow.
2. Hotspots occur only in the ocean basin, not on the continents.
3. The ocean hotspots are found in conjunction with intraplate island chain.
4. Hotspot creates mass anomaly and disturbs the geoids.

Which of the statements given above are correct?

(a) 1, 2 and 3

(b) 2, 3 and 4

(c) 1, 3 and 4

(d) 1, 2 and 4

17. For surface wave propagation, which one of the following relations among group velocity (U), phase velocity (c), wavelength (λ), frequency (f) and period (T) is correct?

(a) $U = c - \lambda \frac{\partial c}{\partial \lambda}$

(b) $U = c^2 \frac{\partial T}{\partial \lambda}$

(c) $U = -\lambda \frac{\partial c}{\partial \lambda}$

(d) $U = c + T \frac{\partial f}{\partial \lambda}$

18. Which one of the following equations is utilized for modelling the density variation with depth inside the Earth?

(a) Adams-Williamson equation

(b) Eikonal equation

(c) Poisson equation

(d) Gardner equation

19. Which one of the following types of triple junction is always stable?

(a) Ridge (R)-Trench (T)-Transform Fault (F)

(b) Ridge (R)-Ridge (R)-Transform Fault (F)

(c) Transform Fault (F)-Transform Fault (F)-Transform Fault (F)

(d) Ridge (R)-Ridge (R)-Ridge (R)

20. Mid-Ocean Ridge Basalt (MORB) is produced at

(a) destructive margins

(b) conservative margins

(c) constructive margins

(d) coastal margins

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21. Which one of the following statements regarding the velocity of Tsunami is correct?

(a) It slows down as it approaches shore.

(b) It increases as it approaches shore.

(c) It remains constant as it approaches shore.

(d) It becomes zero as it approaches shore.

22. The moment magnitude of a fault generating earthquake having seismic moment of 10^{20} N-m will be

(a) 7·27

(b) 6·27

(c) 8·27

(d) 5·27

23. Which one among the following defines the equation of a plane that is tangential to the surface $x^2 + y^2 - z^2 = 4$ at the point (1, 2, – 1)?

(a) $x^2 + y^2 - z^2 - 4 = 0$

(b) $x + y - z - 2 = 0$

(c) $x + 2y + z - 4 = 0$

(d) $x + y + z + 2 = 0$

24. If $\vec{A} = x\hat{i} + y^2\hat{j} + 2z\hat{k}$, then

$$\int_0^1 dx \int_0^1 dy \int_0^1 dz \vec{\nabla} \cdot \vec{A}$$

is

(a) 2

(b) –2

(c) zero

(d) 4

25. Three matrices M_x, M_y, M_z are given as

$$M_x = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}, \quad M_y = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & -i \\ 0 & i & 0 \end{pmatrix},$$

$$M_z = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

Then $[M_y, M_x]$ is

(a) $-2iM_z$

(b) $2iM_z$

(c) $-iM_z$

(d) iM_z

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26. What is the determinant of the following matrix?

$$A = \begin{bmatrix} 5 & 3 \\ 2 & 6 \end{bmatrix}$$

(a) 24

(b) −24

(c) 3

(d) −8

27. A particle lying in the x-y plane is acted upon by a force directed towards the origin whose magnitude is kr, where $r = \sqrt{x^2 + y^2}$ is the distance from the particle to the origin and k is a constant. The work that must be done to move the particle from the origin (0, 0) to the point $x = 1$, $y = 2$ along the direction to that point is

(a) $\frac{k}{2}$ *(b)* $\frac{3k}{2}$

(c) $\frac{5k}{2}$ *(d)* $\frac{7k}{2}$

28. Comet A moves in an elliptical orbit around the Sun. Its distances from the Sun at perihelion and aphelion are $8{\cdot}0 \times 10^7$ km and $4{\cdot}0 \times 10^9$ km, respectively. The semi-major axis of the orbit is

(a) $6{\cdot}63 \times 10^9$ km

(b) $2{\cdot}04 \times 10^9$ km

(c) $6{\cdot}63 \times 10^7$ km

(d) $2{\cdot}04 \times 10^7$ km

29. Imagine a potential

$$V(r) = \frac{c^2}{r - r_0}$$

where c and $r_0 > 0$ are constants. $V(r)$ is used to derive a conserved force $\vec{F}$. Then $\vec{F}$

(a) is only attractive

(b) is only repulsive

(c) can be either attractive or repulsive

(d) cannot be figured out from the available information

30. Which one of the following is true for the range of the forces?

(a) Strong force is long-range, weak force is short-range

(b) Strong force is long-range, electromagnetic force is short-range

(c) Electromagnetic force is long-range, strong force is short-range

(d) Electromagnetic force is long-range, gravitational force is short-range

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31. An object of mass 2 kg collides inelastically with another object of mass 8 kg, which was initially at rest. The two objects stick together after the collision. Then the ratio of final (after collision) to initial (before collision) kinetic energy is equal to

(a) 0·2

(b) 2·0

(c) 0·02

(d) 0·002

32. Conservation of linear momentum

(a) does not ensure the conservation of its components and is valid even when the internal forces are non-conservative

(b) does ensure the conservation of its components and is valid even when the internal forces are non-conservative

(c) does not ensure the conservation of its components and is not valid when the internal forces are non-conservative

(d) does ensure the conservation of its components and is not valid when the internal forces are non-conservative

33. The moment of inertia for a solid cylinder about its axis (passing through the centre of the circular sides) is (where M is the mass of the cylinder and R is the radius of the cylinder)

(a) MR^2

(b) $\frac{1}{2}MR^2$

(c) $\frac{2}{5}MR^2$

(d) $\frac{2}{3}MR^2$

34. The number of degrees of freedom of a rigid rod of negligible thickness in three space dimensions is

(a) 3

(b) 4

(c) 5

(d) 6

35. The observed lifetime of π^+ mesons travelling with speed $V = 0{\cdot}8c$ is (the proper lifetime of π^+ mesons is $2{\cdot}5 \times 10^{-8}$ s and c is the speed of light)

(a) $2{\cdot}5 \times 10^{-8}$ s

(b) $3{\cdot}2 \times 10^{-8}$ s

(c) $4{\cdot}2 \times 10^{-8}$ s

(d) $5{\cdot}2 \times 10^{-8}$ s

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36. The percentage contraction in the length of a rod in a frame of reference, moving with velocity $0 \cdot 8c$ in a direction parallel to its length, is

(a) 20

(b) 40

(c) 60

(d) 80

37. Galilean transformations are

$$x' = x - vt, \quad y' = y, \quad z' = z, \quad t' = t$$

Then t' in the corresponding Lorentz transformations is given by

(a) $t' = t$

(b) $t' = \dfrac{t - \dfrac{vx}{c^2}}{\sqrt{1 + \dfrac{v^2}{c^2}}}$

(c) $t' = \dfrac{t + \dfrac{vx}{c^2}}{\sqrt{1 + \dfrac{v^2}{c^2}}}$

(d) $t' = \dfrac{t - \dfrac{vx}{c^2}}{\sqrt{1 - \dfrac{v^2}{c^2}}}$

38. The sensitivity of the geophysical method is determined by the

(a) ratio of the norm of the perturbation of the data to the norm of the perturbation of the model parameters

(b) ratio of the norm of the perturbation of the model parameters to the norm of the perturbation of the data

(c) norm of the perturbation of the model parameters

(d) norm of the perturbation of the data

39. A Poisson distribution reduces to the binomial distribution when

(a) the number of trials is large and the probability of success in a given trial is also large

(b) the number of trials is small and the probability of success in a given trial is also small

(c) the number of trials is small and the probability of success in a given trial is large

(d) the number of trials is large and the probability of success in a given trial is small

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40. What will be the standard deviation, if the mean of a Poisson distribution is 9?

(a) 3

(b) 6

(c) 9

(d) 12

41. Let X be described by a Gaussian distribution of mean μ and variance σ^2. Then the probability that X lies within 2σ of the mean is

(a) 50·0%

(b) 68·3%

(c) 95·4%

(d) 99·7%

42. An unbiased single six-sided dice is rolled five times. The probability that a 'six' thrown exactly three times is

(a) 0·016

(b) 0·032

(c) 0·048

(d) 0·064

43. Let $\vec{a} = (1, 2, 3)$, $\vec{b} = (2, 4, 6)$ and $\vec{c} = (2, 5, 7)$. Then $(\vec{a} + \vec{b}) \cdot \vec{c}$ is

(a) 33

(b) 66

(c) 99

(d) 11

44. Consider the vectors $\vec{a} = (1, 1, 1)$, $\vec{b} = (1, 2, -3)$, $\vec{c} = (1, -4, 3)$ in a vector space R^3 over a real field R. Which one of the following is correct in this regard?

(a) $\vec{b}$ is orthogonal to $\vec{c}$

(b) $\vec{a}$ is not orthogonal to $(\vec{b} + \vec{c})$

(c) $\vec{a}$ is orthogonal to $\vec{b}$

(d) $\vec{a}$ is not orthogonal to $\vec{c}$

45. The particular solution for

$$\frac{dy}{dx} = -2xy$$

with $y(0) = 1 \cdot 8$ is

(a) $1 \cdot 8e^{-4x^2}$

(b) $1 \cdot 8e^{-3x^2}$

(c) $1 \cdot 8e^{-2x^2}$

(d) $1 \cdot 8e^{-x^2}$

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46. The Wronskian determinant for the two solutions $y_1 = e^{2x}$ and $y_2 = e^{3x}$, satisfying a differential equation, is

(a) e^x

(b) e^{2x}

(c) e^{3x}

(d) e^{5x}

47. A spring having stiffness 700 N/m hangs in a vertical position with its upper end fixed. A mass of 7 kg is attached to the lower end. The equation of motion is given by

(a) $\frac{d^2x}{dt^2} - 100x = 0$

(b) $\frac{d^2x}{dt^2} + 100x = 0$

(c) $\frac{d^2x}{dt^2} - \frac{x}{4900} = 0$

(d) $\frac{d^2x}{dt^2} + \frac{x}{4900} = 0$

48. The function $f(r, \phi)$ is given by a partial differential equation

$$\frac{\partial^2 f}{\partial r^2} + \frac{1}{r^2}\frac{\partial^2 f}{\partial \phi^2} + \frac{2}{r}\frac{\partial f}{\partial r} = 0$$

This equation can precisely be identified with the Laplace equation in spherical coordinates (r, θ, ϕ), when

(a) $\theta = \pi$

(b) $\theta = \frac{\pi}{3}$

(c) $\theta = \frac{\pi}{4}$

(d) $\theta = \frac{\pi}{2}$

49. The differential equation

$$\frac{\partial \vec{f}}{\partial t} + \vec{f} \cdot \vec{\nabla} \vec{f} = \frac{-\vec{\nabla} P}{\rho}$$

is

(a) first-order, linear and inhomogeneous

(b) first-order, non-linear and inhomogeneous

(c) first-order, non-linear and homogeneous

(d) second-order, linear and homogeneous

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50. The root of the equation

$$f(x) = x^2 - 3x + 2$$

in the vicinity of $x = 0$ after 2nd iteration using Newton-Raphson method is (use $x_1 = 0$ as the first approximation)

(a) 0·67

(b) 0·93

(c) 0·98

(d) 1·00

51. Let $I = \int_{-1}^{1} e^x \, dx$. The value of I using Simpson's $\frac{1}{3}$rd rule will be (where $e = 2 \cdot 7182$)

(a) 1·36

(b) 2·36

(c) 3·36

(d) 4·36

52. Runge-Kutta methods are used to find numerical solution of ordinary differential equations. The approximation in the methods uses

(a) only the first-order derivative

(b) only the second-order derivative

(c) only the third-order derivative

(d) higher than third-order derivative

53. Consider two positive charges q and $2q$ at a distance L apart. Let there be another charge Q placed in between q and $2q$, on the line joining them. For the net electrostatic force on Q to be zero, the distance of Q from the charge q should be

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

(b) $\frac{L}{\sqrt{2}-1}$

(c) $\frac{L}{\sqrt{2}+1}$

(d) $\sqrt{2}L - 1$

54. A proton (of charge e and mass m_p) travelling a distance l, after being accelerated from rest by an electric field (of magnitude E), would attain a speed

(a) $\sqrt{2elE/m_p}$

(b) $2l\sqrt{eE/m_p}$

(c) $2l^2eE/m_p$

(d) $\sqrt{2l^3eE/m_p}$

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55. A spherical conductor, carrying a charge Q, is covered by a concentric spherical shell of a linear dielectric material of permittivity ε. If the spherical conductor is of radius a and the spherical shell is of thickness b, then the total energy of the configuration would be

(a) $\frac{Q^2}{8\pi\varepsilon b}\left(\frac{b}{a}+\frac{\varepsilon}{\varepsilon_0}-1\right)$

(b) $\frac{Q^2}{8\pi\varepsilon b}\left(\frac{b}{a}-\frac{\varepsilon}{\varepsilon_0}-1\right)$

(c) $\frac{Q^2}{8\pi\varepsilon b}\left(\frac{b}{a}-\frac{\varepsilon}{\varepsilon_0}+1\right)$

(d) $\frac{Q^2}{8\pi\varepsilon b}\left(\frac{b}{a}+\frac{\varepsilon}{\varepsilon_0}+1\right)$

56. Consider two particles with the same mass m, and charges q_1 and q_2. They traverse identical helical paths in completely opposite senses in a uniform magnetic field $\vec{B} = B_0\hat{k}$, where $\hat{k}$ is the unit vector along the z-axis and B_0 is a constant quantity. Which one of the following is true in this regard?

(a) Both the charged particles have equal momenta along the z-axis

(b) $q_1 = q_2$

(c) $q_1 = -q_2$

(d) No conclusion can be drawn regarding the signs of q_1 and q_2

57. Consider a very long cylindrical conductor of charge per unit length λ. Let E be the magnitude of the electric field due to the cylinder at a perpendicular distance r from its axis. What would be the perpendicular distance at which the electric field would be reduced to $E/2$?

(a) $2r$

(b) $4r$

(c) $r/2$

(d) $r/4$

58. Consider two circular coils of current-carrying wire, having the same magnetic moment. The first coil is of radius 10 cm, has 120 turns, and carries a current of 2·0 A. If the second coil has 150 turns and carries a current of 6·4 A, then what is its radius?

(a) 8·5 cm

(b) 2·5 cm

(c) 5·0 cm

(d) 2·0 cm

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59. Suppose that the electric field due to a spherical distribution of charge is purely radial and is given by

$$E = E_0 r^{-2}(1 - e^{-\lambda r})$$

where E_0, λ are constants. Which one of the following is the correct relationship of r and λ for which the volume charge density would be minimum?

(a) $r = -2/\lambda$

(b) $r = 2\lambda$

(c) $r = 3/\lambda$

(d) $r = 3\lambda$

60. The general solution for a radial potential $V(r)$, obtained by solving the corresponding Laplace equation in spherical polar coordinates, is given by

(a) $V(r) = \alpha + \beta r^2$, where α, β are constants

(b) $V(r) = \alpha + \beta r^2 + \gamma r^4$, where α, β, γ are constants

(c) $V(r) = \alpha + \beta r^{-1}$, where α, β are constants

(d) $V(r) = \alpha \ln r + \beta r^{-1} + \gamma r^{-2}$, where α, β, γ are constants

61. A rectangular pipe, running parallel to the z-axis (from $-\infty$ to ∞), has three grounded metallic sides at $x = 0$, $y = 0$ and $y = a$. The fourth side, at $x = b$, is maintained at a specific potential $V_0(y)$. Which one of the following can be taken as a suitable trial solution for the overall potential $V(x, y)$, to be determined by solving the corresponding two-dimensional Laplace equation?

(a) $(Ae^{ikx} + Be^{-ikx})\cos(ky + \delta)$, where A, B, k, δ are constants

(b) $(Ae^{ikx} + Be^{iky})(C\sin kx + D\cos ky)$, where A, B, C, D, k are constants

(c) $(Ae^{kx} + Be^{-kx})(C\sin ky + D\cos ky)$, where A, B, C, D, k are constants

(d) $(Ae^{ikx} + Be^{-ikx})\sin(ky + \delta)$, where A, B, k, δ are constants

62. A rotor generates a maximum induced emf of 50 V, while rotating at a rate of 120 rpm. What should be the rate of rotation in order that a maximum induced emf of 75 V is generated?

(a) 240 rpm

(b) 360 rpm

(c) 320 rpm

(d) 180 rpm

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63. Consider a parallel-plate capacitor with a $2 \cdot 0\ \mu F$ capacitance. At what rate should the potential difference between the plates of the capacitor be changed to produce a displacement current of 1·5 A?

(a) $7 \cdot 5 \times 10^5$ V/s

(b) $9 \cdot 25 \times 10^4$ V/s

(c) $5 \cdot 25 \times 10^4$ V/s

(d) $4 \cdot 5 \times 10^5$ V/s

64. A battery of fixed emf ε and internal resistance R_B is connected to a variable load of resistance R_L. The power delivered to the load will be maximum for

(a) $R_L = 0 \cdot 5 R_B$

(b) $R_L = 0 \cdot 25 R_B$

(c) $R_L = R_B$

(d) $R_L = 2R_B$

65. Which one of the following is correct for a current of finite density $\vec{J}$ flowing through a perfect conductor?

(a) The magnetic field vanishes

(b) The magnetic field is in general non-zero, but irrotational

(c) The magnetic field decays exponentially with time

(d) The magnetic field is time-independent

66. A current I flows down a wire of uniform cross-sectional area α and length l. If the potential difference at the ends of the wire is V, then the magnitude of the Poynting vector would be

(a) $\frac{2lVI}{\sqrt{3\pi\alpha}}$

(b) $\frac{VI}{2l\sqrt{\pi\alpha}}$

(c) $\frac{lVI}{2\sqrt{\pi\alpha}}$

(d) $\frac{VI}{l\sqrt{3\pi\alpha}}$

67. A monochromatic plane electromagnetic wave of amplitude E_0, frequency ω and zero phase angle travels in the negative x-direction and is polarized in the z-direction. The electric and magnetic field vectors for the wave can be expressed as

(a) $\vec{E}(\vec{x}, t) = E_0 \hat{z} \sin\left[\omega\left(t - \frac{x}{c}\right)\right]$,

$\vec{B}(\vec{x}, t) = \frac{E_0}{c} \hat{y} \cos\left[\omega\left(t - \frac{x}{c}\right)\right]$

(b) $\vec{E}(\vec{x}, t) = E_0 \hat{z} \sin\left[\omega\left(t + \frac{x}{c}\right)\right]$,

$\vec{B}(\vec{x}, t) = \frac{E_0}{c} \hat{x} \cos\left[\omega\left(t + \frac{x}{c}\right)\right]$

(c) $\vec{E}(\vec{x}, t) = E_0 \hat{z} \cos\left[\omega\left(t - \frac{x}{c}\right)\right]$,

$\vec{B}(\vec{x}, t) = \frac{E_0}{c} \hat{x} \cos\left[\omega\left(t - \frac{x}{c}\right)\right]$

(d) $\vec{E}(\vec{x}, t) = E_0 \hat{z} \cos\left[\omega\left(t + \frac{x}{c}\right)\right]$,

$\vec{B}(\vec{x}, t) = \frac{E_0}{c} \hat{y} \cos\left[\omega\left(t + \frac{x}{c}\right)\right]$

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68. The frequency of oscillation of the current in an L-C circuit is given by

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$

where L and C denote the inductance and capacitance, respectively. What inductance should be connected to a 20 pF capacitor in an oscillator capable of generating 600 nm electromagnetic waves?

(a) $\frac{3}{\pi^2} \times 10^{-21}$ H

(b) $\frac{5}{\pi^2} \times 10^{-21}$ H

(c) $\frac{5}{\pi^2} \times 10^{-20}$ H

(d) $\frac{3}{\pi^2} \times 10^{-20}$ H

69. The electric and magnetic fields derived respectively from the scalar and vector potentials

$$\phi(\vec{r}, t) = \phi_0, \quad \vec{A}(\vec{r}, t) = \frac{A_0 t^2}{r^3}\vec{r}$$

are given by (where ϕ_0, A_0 are constants)

(a) $\vec{E}(\vec{r}, t) = -\frac{3A_0 t^2}{r^4}\vec{r}$,

$$\vec{B}(\vec{r}, t) = \frac{A_0 t^2}{r^4}\vec{\nabla} \times \vec{r}$$

(b) $\vec{E}(\vec{r}, t) = -\frac{2A_0 t}{r^3}\vec{r}$, $\vec{B}(\vec{r}, t) = 0$

(c) $\vec{E}(\vec{r}, t) = \left(\phi_0 r - \frac{A_0 t^2}{2r^4}\right)\vec{r}$, $\vec{B}(\vec{r}, t) = 0$

(d) $\vec{E}(\vec{r}, t) = \phi_0\vec{r} + \frac{2A_0 t}{r^3}\vec{\nabla} r$,

$$\vec{B}(\vec{r}, t) = -\frac{3A_0 t^2}{r^4}\vec{\nabla} \times \vec{r}$$

70. The magnitude of magnetic field for a plane electromagnetic wave is

$$B = (200\ \mu\text{T})\sin\left[(4 \times 10^{15}\ \text{s}^{-1})\left(t - \frac{x}{c}\right)\right]$$

What would be the average energy density corresponding to the electric field of the wave, in terms of the permittivity of free space ε_0, in SI units?

(a) $(2{\cdot}7 \times 10^8)\varepsilon_0$

(b) $(1{\cdot}8 \times 10^9)\varepsilon_0$

(c) $(2{\cdot}7 \times 10^9)\varepsilon_0$

(d) $(1{\cdot}8 \times 10^8)\varepsilon_0$

71. The regular diurnal variations in the Earth's magnetic field are caused by

(a) changes in strength and direction of ionospheric currents

(b) thunderstorm activities

(c) rotation of the Earth

(d) auroras

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72. The relation between water saturation (S_w) and formation water resistivity (R_w) based on Archie's empirical equation is (where ϕ = porosity, R_t = true resistivity, a = constant, m = cementation factor, n = saturation exponent)

(a) $S_w = \left[\left(\frac{a}{\phi^m}\right) \times \left(\frac{R_w}{R_t}\right)\right]^{1/n}$

(b) $S_w = \left[\left(\frac{a}{\phi}\right) \times \left(\frac{R_w}{R_t}\right)\right]$

(c) $S_w = [(a\phi) \times (R_w R_t)]$

(d) $S_w = [(a\phi) \times (R_w R_t)]^{1/n}$

73. What will be the approximate porosity of a formation, if the bulk, matrix and fluid densities of the formation are 2·50 g /cm^3, 2·71 g /cm^3 and 1·10 g /cm^3, respectively?

(a) 13%

(b) 20%

(c) 22%

(d) 25%

74. Which one of the following boundary conditions in electromagnetic method is ***not*** correct?

(a) The electric field tangential to the interface is continuous

(b) The magnetic field tangential to the interface is continuous

(c) The current density normal to the interface is continuous

(d) The magnetic flux tangential to the interface is continuous

75. If gravity measuring station is located 50 m above the reference ellipsoid, what will be the free-air correction on the observed gravity data?

(a) 15·43 mGal

(b) 17·36 mGal

(c) 12·25 mGal

(d) 20·05 mGal

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76. An electromagnetic wave at 100 Hz can penetrate to a depth of 100 m. The depth of penetration in the same media for electromagnetic wave at 400 Hz will be

(a) 2·5 m

(b) 50 m

(c) 200 m

(d) 400 m

77. In optically pumped magnetometer, the splitting of the energy levels in the presence of a magnetic field is called

(a) Doppler effect

(b) proton precession

(c) Zeeman effect

(d) magnetic saturation

78. The maximum gravity anomaly and the half-width of the gravity anomaly profile curve over a sphere are 0·1 mGal and 35 m, respectively. The depth to the centre of the sphere from surface and mass of the sphere are

(a) 32·5 m and 3000 tonnes, respectively

(b) 45·5 m and 3123·75 tonnes, respectively

(c) 25 m and 3197·25 tonnes, respectively

(d) 35 m and 1225 tonnes, respectively

79. Which one of the following electrode arrays provides good vertical resolution but poor depth of penetration?

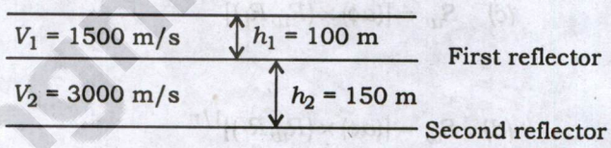
(a) Dipole-dipole

(b) Wenner

(c) Schlumberger

(d) Square

80. What is the approximate average velocity (V_{ave}) along the zero-offset reflection path to the second reflector for the following model?



(a) 2250 m/s

(b) 2143 m/s

(c) 3143 m/s

(d) 2150 m/s

81. Which of the following is/are type(s) of coherent seismic noise in a layered medium?

(a) Vehicular noise

(b) Ground roll only

(c) Multiple reflection only

(d) Ground roll and multiple reflection both

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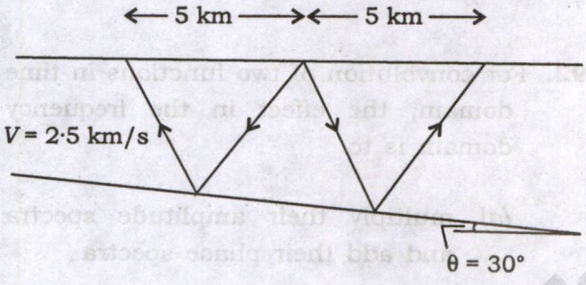
82. A reflection survey indicates a depth of 750 m to the first reflector between the two layers, which have their velocities $V_1 = 1500$ m/s and $V_2 = 2500$ m/s. What will be the two-way reflection time at 1500 m offset?

(a) 2·414 s *(b)* 3·414 s

(c) 4·414 s *(d)* 1·414 s

83. Consider the following basic geometry of the reflected ray path :



What will be the dip moveout for a single dipping reflector with 30° dip, beneath a homogeneous top layer of velocity 2·5 km/s?

(a) 2 s *(b)* 4 s

(c) 0·5 s *(d)* 6 s

84. If the travel time of a seismic wave at 10 m offset and zero-offset are 375 ms and 125 ms, respectively, the velocity in the medium will be

(a) 40 m/s *(b)* 80 m/s

(c) 20 m/s *(d)* 225 m/s

85. To prevent aliasing, a filter must be applied before sampling or resampling to a larger sample period, and a filter must be applied to limit frequencies

(a) to above Nyquist

(b) to below Nyquist

(c) equal to Nyquist

(d) twice of Nyquist

86. The spectra cross at the frequency

$$\frac{F_s}{2} = \frac{1}{2T} \text{ Hz}$$

is known as (where F_s is the sampling frequency)

(a) dominant frequency

(b) resonance frequency

(c) folding frequency

(d) Nyquist frequency

87. The Fourier transform of a boxcar function is

(a) boxcar function

(b) square function

(c) step function

(d) sinc function

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88. What will be the Fourier transform of the derivative of $x(t)$, if the Fourier transform of a function $x(t)$ is $X(\omega)$?

(a) $\frac{X(f)}{jf}$ *(b)* $j\omega X(\omega)$

(c) $-\frac{1}{j\omega}X(\omega)$ *(d)* $jfX(f)$

89. The Fourier transform of the Gaussian function is

(a) sinc function

(b) boxcar function

(c) Gaussian function

(d) delta function

90. Consider the following statements regarding convolution operation :

1. The effect of a filter is mathematically described by convolution operation.
2. Convolution operation does not convolve the input signal and impulse response.
3. Convolution operation convolves the input signal and impulse response.
4. Convolution operation describes output of a Linear Time Invariant (LTI) system.

Which of the statements given above are correct?

(a) 1 and 3 only

(b) 3 and 4 only

(c) 1, 2 and 4

(d) 1, 3 and 4

91. What will be the complementary error function $erfc(x)$, if the error function

$$erf(x) = (1/\pi^{1/2})\int_0^x e^{-u^2}du?$$

(a) $erfc(x) = 1 - erf(x)$

(b) $erfc(x) = 1 + erf(x)$

(c) $erfc(x) = \frac{1}{erf(x)}$

(d) $erfc(x) = 2erf(x)$

92. For convolution of two functions in time domain, the effect in the frequency domain is to

(a) multiply their amplitude spectra and add their phase spectra

(b) divide their amplitude spectra and add their phase spectra

(c) multiply their amplitude spectra and subtract their phase spectra

(d) multiply their phase spectra and add their amplitude spectra

93. The value of Dirac delta $\delta(t)$ at $t = 0$ will be

(a) zero

(b) +1

(c) −1

(d) ∞

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94. A unit step function $u(t)$ is discontinuous at

(a) $t = 0$

(b) $t = -1$

(c) $t = 1$

(d) $t = \infty$

95. The spectrum of a harmonic signal in the time and frequency domain is

(a) square wave

(b) triangular wave

(c) spike wave

(d) cosine wave

96. When size of particles is very small compared to the wavelength of the radiation, which of the following scattering processes is/are expected to occur?

(a) Mie only

(b) Non-selective only

(c) Rayleigh

(d) Mie and non-selective

97. The apparent change in frequency due to motion of the source and/or observer is known as

(a) dispersion effect

(b) scattering effect

(c) Doppler effect

(d) path attenuation effect

98. If the frequency of an electromagnetic radiation is doubled, its wavelength becomes

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

(b) 2 times of original

(c) $\frac{1}{4}$ of original

(d) 4 times of original

99. Which one of the following regions of the electromagnetic spectrum enables us to see through clouds?

(a) Visible region

(b) Shortwave infrared region

(c) Microwave region

(d) Ultraviolet region

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100. What kind of electromagnetic waves would dominantly reach the Earth surface, if the temperature of the Sun reduces by half?

(a) Infrared

(b) Ultraviolet

(c) Green light

(d) Visible

101. The ratio of the energy of a photon of 2000 Å wavelength to that of 4000 Å wavelength is

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

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

(c) 2

(d) 4

102. Total radiation emitted by a black-body depends upon the temperature of the emitting surface (fourth power of its absolute temperature). This corresponds to

(a) Stefan-Boltzmann law

(b) Planck's law

(c) Wien's displacement law

(d) Debye's law

103. The Planck's black-body radiation graph at sufficient long wavelengths can be approximated with a line of slope

(a) –2

(b) –3

(c) –4

(d) –5

104. A system experiences a change of temperature from T_i to T_f during the heat transfer of Q units. What would be the average heat capacity of the system?

(a) $\frac{T_f - T_i}{Q}$

(b) $\frac{Q}{T_f - T_i}$

(c) $\frac{T_i - T_f}{Q}$

(d) $\frac{Q}{T_i - T_f}$

105. In a scattering experiment, the atomic mass of the target nucleus is 27 times the atomic mass of the projectile nucleus. The ratio of the radius of the target nucleus to the radius of the projectile nucleus is

(a) 27

(b) 81

(c) 9

(d) 3

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106. Which one of the following experimental methods is ***not*** used to measure nuclear matter distribution?

(a) Rutherford scattering

(b) Electron scattering

(c) Alpha decay

(d) π-Mesic X-rays

107. Which one of the following statements is true about the nuclear density of $^{12}_{6}C$ and $^{238}_{92}U$ nucleus?

(a) $^{238}_{92}U$ is more dense than $^{12}_{6}C$.

(b) $^{12}_{6}C$ is more dense than $^{238}_{92}U$.

(c) Both the nuclei have the same nuclear density.

(d) Nuclear density depends on the abundance of the element.

108. The fission chain reaction will be subcritical when multiplication factor (k) is

(a) equal to zero

(b) equal to one

(c) greater than one

(d) less than one

109. Consider the following equation for a fission process :

$$^{1}_{0}n + {}^{235}U \rightarrow [^{236}U] \rightarrow {}^{94}_{38}Sr + Y + 2\,{}^{1}_{0}n + Q$$

where Q is the energy released in the fission process. Then the nucleus Y is

(a) $^{140}_{54}Xe$

(b) $^{140}_{56}Ba$

(c) $^{136}_{54}Xe$

(d) $^{136}_{56}Ba$

110. According to the Geiger-Nuttall law, the range of an α-particle is proportional to

(a) square of its initial velocity

(b) square root of its initial velocity

(c) cube of its initial velocity

(d) cube root of its initial velocity

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111. The mass of $^{60}_{27}Co$ required to produce an activity of 10 Ci is (given, the half-life of $^{60}_{27}Co$ is 5·26 years)

(a) 0·08 mg

(b) 0·88 mg

(c) 8·8 mg

(d) 88 mg

112. An incident gamma ray interacts with a nearly free electron only during

(a) Compton scattering

(b) pair production

(c) photoelectric effect

(d) Auger effect

113. What will be the half-life of a radioactive substance whose activity drops to $\frac{1}{16}$th of its initial value in 40 years?

(a) 2 years

(b) 8 years

(c) 10 years

(d) 16 years

114. Which one of the following rocks has maximum ^{40}K background activity?

(a) Basalt

(b) Ultramafic

(c) Chondrite

(d) Granite

115. The actinium series for natural radioactivity starts from

(a) $^{232}_{90}Th$

(b) $^{227}_{89}Ac$

(c) $^{238}_{92}U$

(d) $^{235}_{92}U$

116. Which one of the following radiation detectors provides the best energy resolution to measure the energy of gamma rays?

(a) Geiger-Müller counter

(b) Scintillator detector

(c) Ionization chamber

(d) Germanium detector

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117. In a scintillation detector, the role of the photocathode is

(a) to amplify the number of scintillation photons produced by the scintillator

(b) to amplify the number of electrons produced in the photomultiplier tube

(c) to convert the scintillation light emitted from the scintillator to photoelectrons

(d) to convert the electrons of the scintillator to scintillation light

118. The kinetic energy of a proton, whose de Broglie wavelength is about 1 fm, is approximately (where proton rest mass energy = 938 MeV and $h = 6{\cdot}63 \times 10^{-34}$ J-s)

(a) 600 MeV

(b) 1200 MeV

(c) 938 MeV

(d) 1836 MeV

119. Davisson and Germer experiment on electron scattering from a solid surface confirms the

1. particle nature of the electron
2. variation of number of scattered electrons with the angle between the incoming beam and the direction of scattering
3. existence of de Broglie waves

Select the correct answer using the code given below.

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

120. For $n = 4$ states of hydrogen atom, the maximum value of L_z (z-component of orbital angular momentum $\vec{L}$) is

(a) $1\hbar$

(b) $2\hbar$

(c) $3\hbar$

(d) $4\hbar$

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