General Aptitude

Q.1 – Q.5 Carry ONE mark Each

Q.1	Is there any good show _____ television tonight? Select the most appropriate option to complete the above sentence.
(A)	in
(B)	at
(C)	within
(D)	on

Q.2	As the police officer was found guilty of embezzlement, he was _____ dismissed from the service in accordance with the Service Rules. Select the most appropriate option to complete the above sentence.
(A)	sumptuously
(B)	brazenly
(C)	unintentionally
(D)	summarily

Q.3	The sum of the following infinite series is:
	$$\frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \frac{1}{5!} + \cdots$$
(A)	π
(B)	$1 + e$
(C)	$e - 1$
(D)	e

Q.4	A thin wire is used to construct all the edges of a cube of 1 m side by bending, cutting and soldering the wire. If the wire is 12 m long, what is the minimum number of cuts required to construct the wire frame to form the cube?
(A)	3
(B)	4
(C)	6
(D)	12

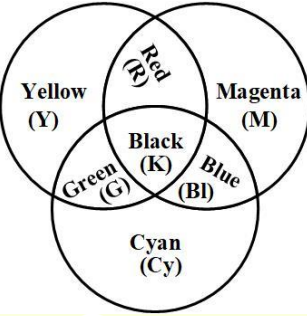| Q.5	The figures I, II and III are parts of a sequence. Which one of the following options comes next in the sequence at IV?
	I II III ? IV
(A)	
(B)	
(C)	
(D)	
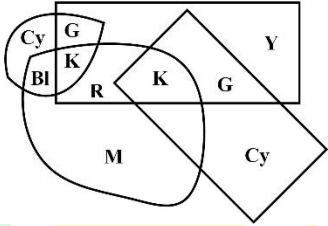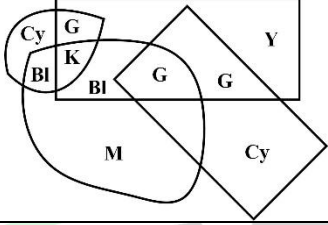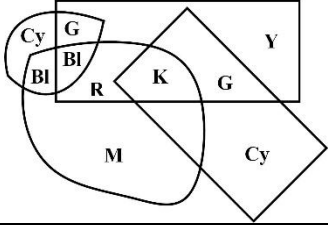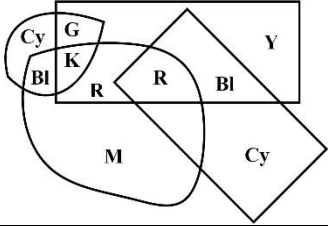
Q.6 – Q.10 Carry TWO marks Each

Q.6	"Why do they pull down and do away with crooked streets, I wonder, which are my delight, and hurt no man living? Every day the wealthier nations are pulling down one or another in their capitals and their great towns: they do not know why they do it; neither do I. It ought to be enough, surely, to drive the great broad ways which commerce needs and which are the life-channels of a modern city, without destroying all history and all the humanity in between: the islands of the past." (From Hilaire Belloc's "The Crooked Streets") Based only on the information provided in the above passage, which one of the following statements is true?
(A)	The author of the passage takes delight in wondering.
(B)	The wealthier nations are pulling down the crooked streets in their capitals.
(C)	In the past, crooked streets were only built on islands.
(D)	Great broad ways are needed to protect commerce and history.
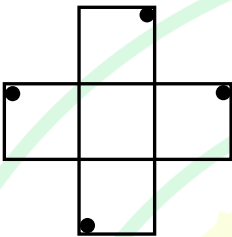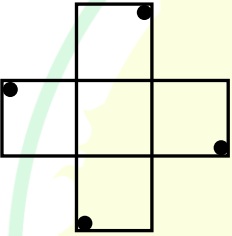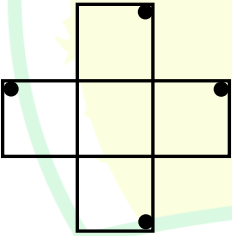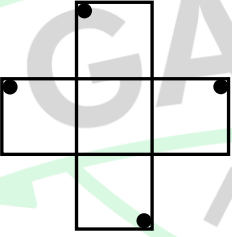
Q.7	Rohit goes to a restaurant for lunch at about 1 PM. When he enters the restaurant, he notices that the hour and minute hands on the wall clock are exactly coinciding. After about an hour, when he leaves the restaurant, he notices that the clock hands are again exactly coinciding. How much time (in minutes) did Rohit spend at the restaurant?
(A)	$64\frac{6}{11}$
(B)	$66\frac{5}{13}$
(C)	$65\frac{5}{11}$
(D)	$66\frac{6}{13}$

Q.8	A color model is shown in the figure with color codes: Yellow (Y), Magenta (M), Cyan (Cy), Red (R), Blue (Bl), Green (G), and Black (K). Which one of the following options displays the color codes that are consistent with the color model?
(A)	
(B)	
(C)	
(D)	

Q.9	A circle with center at $(x, y) = (0.5, \ 0)$ and radius $= 0.5$ intersects with another circle with center at $(x, y) = (1, 1)$ and radius $= 1$ at two points. One of the points of intersection (x, y) is:
(A)	$(0, 0)$
(B)	$(0.2, 0.4)$
(C)	$(0.5, 0.5)$
(D)	$(1, 2)$

Q.10	An object is said to have an n-fold rotational symmetry if the object, rotated by an angle of $\dfrac{2\pi}{n}$, is identical to the original.
	Which one of the following objects exhibits 4-fold rotational symmetry about an axis perpendicular to the plane of the screen?
	Note: The figures shown are representative.
(A)	
(B)	
(C)	
(D)	

PART A: COMPULSORY SECTION FOR ALL CANDIDATES

Q.11– Q .17 Carry ONE mark Each

Q.11	The most volcanically active body in our Solar System is
(A)	Mars
(B)	Io
(C)	Moon
(D)	Venus
Q.12	A type of fold which is relatively sharp and angular at its synformal and antiformal hinges is known as
(A)	Fan fold
(B)	Drag fold
(C)	Chevron fold
(D)	Dome
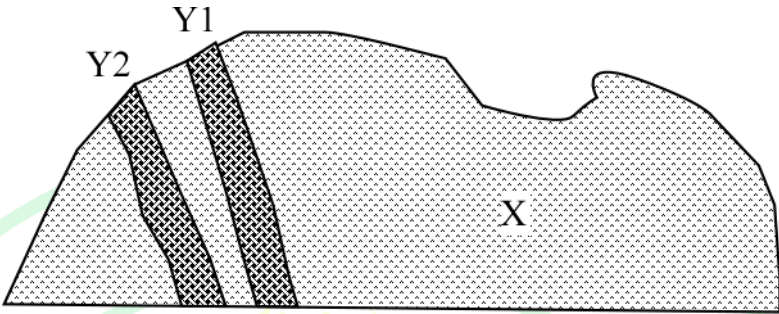
Q.13	Which one of the following geophysical methods can provide information on deep Earth structures (of the order of 1000 km) with highest resolution?
(A)	Seismic methods
(B)	Magnetic methods
(C)	Electrical methods
(D)	Gravity methods
Q.14	The continuous series of Bowen's reaction series is represented by
(A)	the orthoclase - albite feldspar system
(B)	the anorthite - albite system
(C)	the forsterite - fayalite system
(D)	the diopside - anorthite system

Q.15	Which of the following time boundaries correspond(s) to major mass extinction events?
(A)	Cretaceous - Paleogene
(B)	Paleogene - Neogene
(C)	Permian - Triassic
(D)	Precambrian - Cambrian
Q.16	A watershed has an area of 74 km^2. The stream network within this watershed consists of three different stream orders. The stream lengths in each order are as follows: Ist order streams: 3 km, 2.5 km, 4 km, 3 km, 2 km, 5 km IInd order streams: 10 km, 15 km, 7 km IIIrd order streams: 30 km The drainage density of the watershed is _____ km/km^2 *(Round off to two decimal places)*

Q.17	A sample contains 7 wt% CaO and 5 wt% MgO. The molar ratio of CaO to MgO in the sample is _____ *(Round off to two decimal places)*

Q.18 – Q .26 Carry TWO marks Each

Q.18	Select the option that lists oxide minerals only.
(A)	Spinel, Corundum, Rutile
(B)	Olivine, Pyroxene, Magnetite
(C)	Apatite, Galena, Monazite
(D)	Fluorite, Halite, Calcite

Q.19	Consider two intersecting, north-easterly striking and south-easterly dipping dikes Y1 and Y2, which are exposed on an east-west trending vertical wall of a granite (X) quarry as shown below.
	The angle that the dikes make with the horizontal on the quarry wall is
(A)	true dip
(B)	apparent dip
(C)	rake
(D)	attitude of foliation

Q.20	The ratio of P-wave to S-wave velocities, V_p/V_s, within the Earth depends on
(A)	bulk modulus
(B)	shear modulus
(C)	density
(D)	coefficient of internal friction
Q.21	Three pixels P, Q, and R in an image are characterized by the NDVI values of $+0.84$, $+0.01$, and -0.89, respectively. Which of the following options is/are correct?
(A)	P is from vegetation area and Q is from barren land
(B)	Q is from water body and R is from barren land
(C)	Q is from barren land and R is from water body
(D)	P is from vegetation area and Q is from water body

Q.22	Which of the following can indicate the presence of significant sub-surface iron mineralization?
(A)	Free air gravity anomaly
(B)	Bouguer gravity anomaly
(C)	Magnetic anomaly
(D)	Electrical resistivity measurements
Q.23	Which of the following statements is/are correct regarding the magnetic field lines of the Earth, at the magnetic poles and the magnetic equator?
(A)	Horizonal at the equator
(B)	Vertical at the poles
(C)	Horizonal at the poles
(D)	Vertical at the equator

| Q.24	If the lowest Digital Number (DN) value in an image of 10-bit radiometric resolution is 0, then the maximum DN value of that image is _____ (*Answer in integer*)
Q.25	If one liter of water at pH 7 is mixed with one liter of water at pH 6, the resulting pH of the mixture is _____ (*Round off to two decimal places*)

Q.26	A hillslope is shown below. If the area over the failure plane is 50 m^2 and the weight of the hillslope material (W) is 2000 tons, the Factor of Safety (FOS) for this hillslope in dry conditions is _____
	(Cohesion along failure plane = 196 KPa, dip of failure plane = 60°, and internal friction angle = 30°).
	(Round off to two decimal places)
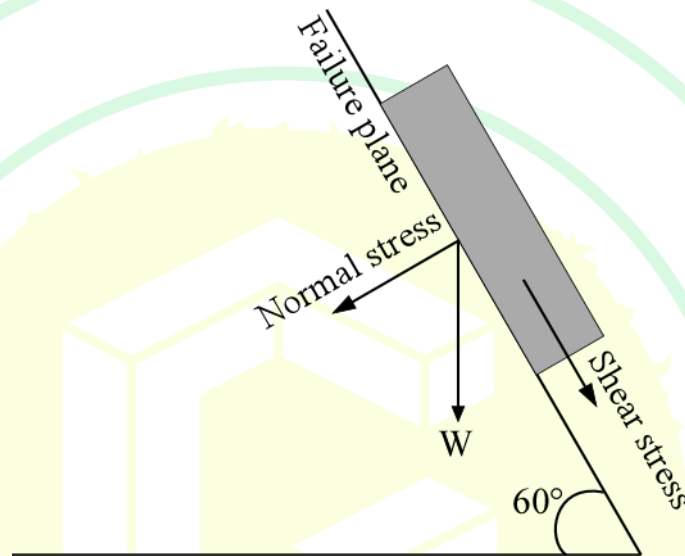
PART B (SECTION 2): FOR GEOPHYSICS CANDIDATES ONLY

Q.27 – Q.44 Carry ONE mark Each

Q.27	A scalar potential ψ of a vector field, **F**, satisfies the Laplace equation ($\nabla^2\psi = 0$) in free space. ψ can be uniquely determined at any point inside the closed surface S using
(A)	$\nabla.\mathbf{F} = 0$
(B)	$\nabla \times \mathbf{F} = 0$
(C)	$\psi(\mathbf{x}) = $ constant, $\mathbf{x} \in S$
(D)	$\nabla.\mathbf{F} \neq 0$
Q.28	In resistivity measurements for a double-dipole system, the apparent resistivity is NOT affected by
(A)	the electrode spacing
(B)	the resistivity of the subsurface
(C)	the distance between the centers of the current and potential dipoles
(D)	the telluric current

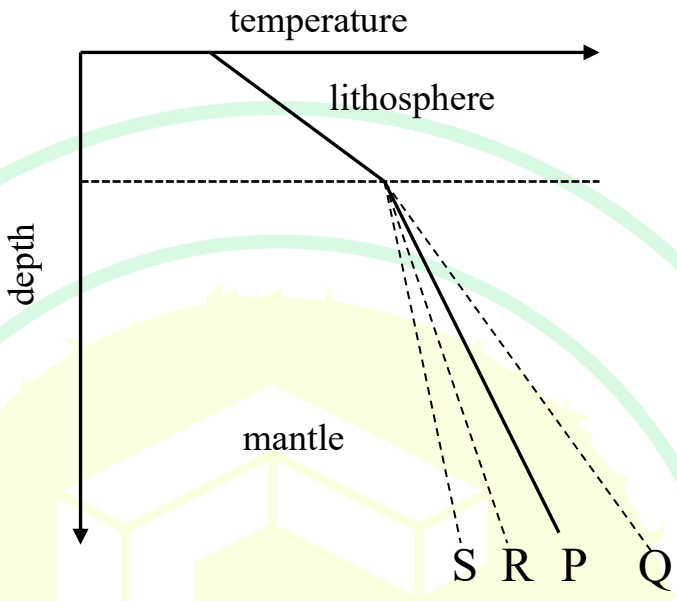| Q.29	The working of the proton-precession magnetometer is based on
(A)	the magnetic moment of hydrogen-atom nucleus being proportional to the angular momentum of its spin
(B)	the fact that oxygen is diamagnetic
(C)	the fact that the lowest energy level of electrons is in the ground state
(D)	the Zeeman effect
Q. 30	Which one of these statements is NOT correct for electromagnetic waves travelling through the subsurface?
(A)	They cannot travel without attenuation
(B)	They are subject to diffraction
(C)	They are analogous to seismic P waves
(D)	They can be used to detect highly conductive ore bodies

Q. 31	Diurnal correction in magnetic survey data accounts for
(A)	geomagnetic polarity reversals
(B)	charged particles in ionosphere
(C)	the westward drift of the Earth's magnetic field
(D)	the lunar magnetic field
Q. 32	Which one of the following options is the primary contributor to the International Geomagnetic Reference Field?
(A)	Ionospheric magnetic field
(B)	Magnetic field generated in the outer core
(C)	Crustal magnetic field
(D)	Solar magnetic field

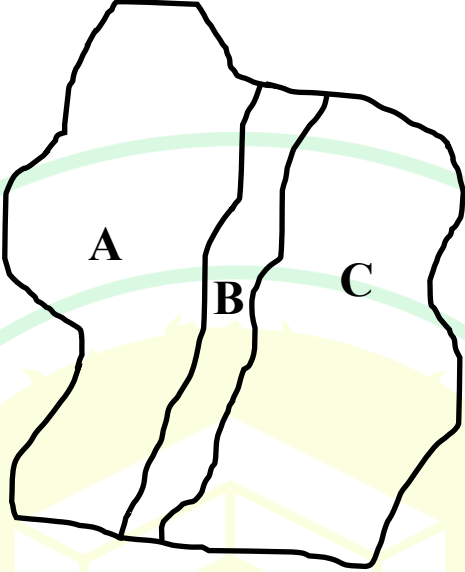| Q. 33	If a planet is made of uniform density material and has no topography, then which one of the following statements is correct?
(A)	The geoid surface would be higher than the reference ellipsoid surface
(B)	The geoid surface would be lower than the reference ellipsoid surface
(C)	The geoid and the reference ellipsoid surfaces would coincide
(D)	The geoid surface would be lower in some places, and higher in other places, with respect to the reference ellipsoid
Q. 34	Which one of the following factors leads to an abrupt increase in density at the mantle-outer core boundary?
(A)	Composition change
(B)	Temperature change
(C)	Phase change
(D)	Viscosity change

Q. 35	Which one of the options is correct about β^- decay?
(A)	Atomic number increases and mass number remains constant
(B)	Atomic weight increases and atomic number remains constant
(C)	Number of protons increases and number of neutrons remains constant
(D)	Number of neutrons increases and number of protons remains constant

Q. 36	F denotes force, A denotes area, L denotes length, and ΔL is the change in length due to the applied force. Assuming linear elasticity, select a relationship where the constant of proportionality is a material property independent of the dimensions of the body.
(A)	F ∝ ΔL
(B)	F ∝ ΔL/L
(C)	F ∝ A × ΔL/L
(D)	F ∝ ΔL × L/ A

Q. 37	In a gravity survey that is being carried out in the vicinity of a large mountain, it was observed that the deflection of the plumb line from the vertical is less than what is calculated using the visible mountain mass. Which one of the inferences about the mountain is correct?
(A)	It has a high-density root
(B)	It has no root
(C)	It has a low-density root
(D)	It has a high-density anti-root

Q.38	In the schematic, line P shows a 1-D geothermal profile. If the heat flow at the base of the mantle increases, which line will reflect the new geothermal profile?
(A)	Line Q
(B)	Line R
(C)	Line S
(D)	Line P

Q.39	The following figure shows the GPS data at two stations located near each other at the same latitude. Station A is moving towards the west while station B is moving towards the east. Which one of the following options is correct?
(A)	A and B are located on two sides of a convergent boundary
(B)	A and B are located on two sides of a transform boundary
(C)	A and B are located on two sides of a divergent boundary
(D)	A and B are parts of the same plate

Q. 40	The following figure shows a region in which rocks in areas A, B and C follow Hooke's law and are subject to the same stress. B exhibits lower strain than both A and C. What can we infer about the nature of B?
(A)	B is part of a plate boundary
(B)	B has higher heat flow values compared to A and C
(C)	B is made up of rocks of lower density compared to A and C
(D)	B is made up of rocks that have higher strength compared to A and C

Q. 41	What is/are the primary effect(s) of applying upward continuation to magnetic field data?
(A)	Decrease in the relative influence of shallow magnetic sources
(B)	Increase in the relative influence of deeper magnetic sources
(C)	Improvement in the detection of near-surface magnetic sources
(D)	Movement of shallow magnetic sources closer to the observation plane
Q. 42	Half-life of ^{14}C is 5730 years. Suppose we start with 1 billon ^{14}C atoms and after a certain interval of time only 125 million ^{14}C atoms remain, the number of half-lives that has elapsed is _____ (*Answer in integer*)
Q.43	When an external magnetic field of strength $1.5 \times 10^{-3} A/m$ is applied to a rock sample, the measured intensity of magnetization is $0.5 \times 10^{-3} A/m$. The magnetic susceptibility of this rock is _____ (*Round off to two decimal places*)

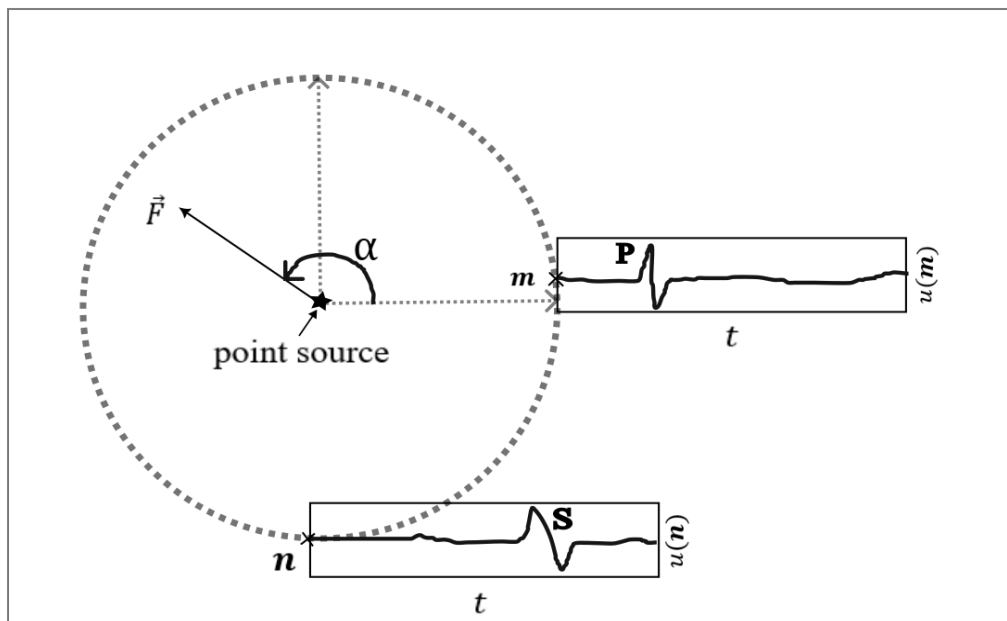| Q.44	If seismic signals of periods greater than 10 s are of interest, the minimum sampling frequency should be _____ Hz. (*Round off to one decimal place*)

Q.45 – Q .65 Carry TWO marks Each

Q.45	The components u, v, w of the displacement field along x, y, z directions, respectively, are given by $$u = -\sin(\omega t - kz)$$ $$v = \sin(\omega t - kz)$$ $$w = 0$$ where, t, k, and ω are time, wavenumber, and angular frequency, respectively. Assuming k is real, which one of the following options describes the wave?
(A)	An S-wave propagating in the z direction
(B)	A P-wave propagating in the z direction
(C)	A Rayleigh wave with elliptical motion in the xy plane
(D)	An S-wave travelling in the x direction

Q.46	Select the correct statement regarding surface waves and upper mantle structure.
(A)	Surface waves cannot be used to infer the upper mantle structure as the amplitudes decay with increasing distance from the surface
(B)	Surface waves can be used to infer the upper mantle structure as surface wave phase velocity varies with frequency
(C)	Surface waves can be used to infer the upper mantle structure as the shear-wave velocity of the medium changes with frequency
(D)	Surface waves cannot be used to infer the upper mantle structure as surface waves travel only along the surface and are not sensitive to the Earth's internal structure

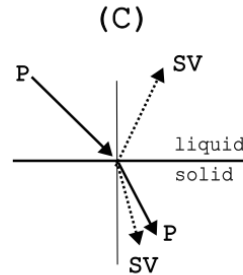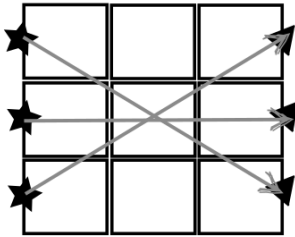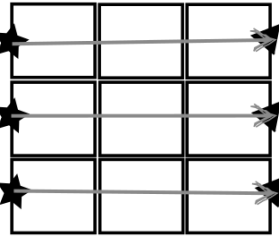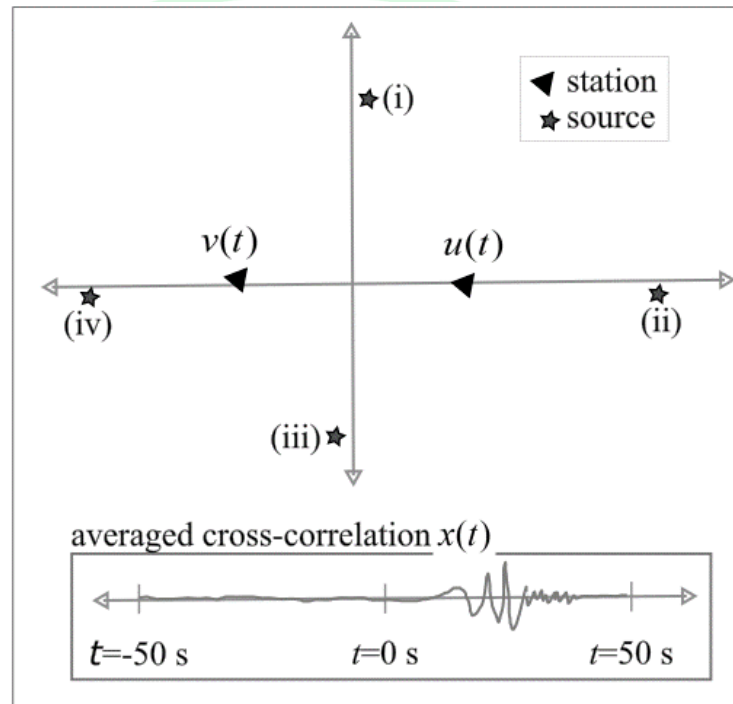| Q.47	A geophysicist is analyzing the elastic-wave radiation to infer the body force equivalent of a seismic source. She has plotted the horizontal component of the displacement field, denoted as $u(\boldsymbol{m}, t)$, for time t and location $\boldsymbol{m}$. The measured field at two locations $\boldsymbol{m}$ and $\boldsymbol{n}$ is plotted in the figure. Note that **S** and **P** waves have negligible amplitudes at locations $\boldsymbol{m}$ and $\boldsymbol{n}$, respectively. Assuming a homogeneous medium, select the most probable direction (specified by the angle α) along which the force $\vec{F}$ is applied.
(A)	$\alpha = 0°$
(B)	$\alpha = 90°$
(C)	$\alpha = 135°$
(D)	$\alpha = 315°$
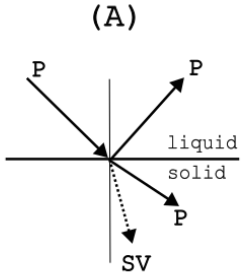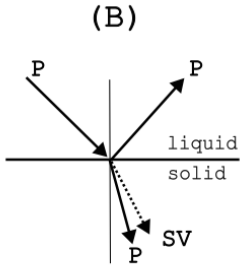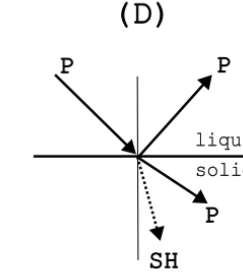
Q.48	For a horizontal liquid-solid interface as shown, which one of the following ray diagrams with an incident P wave is correct? SH and SV denote shear-horizontal and shear-vertical waves, respectively.
(A)	A
(B)	B
(C)	C
(D)	D

Q.49	Consider a steady state heat conduction equation for the Earth's crust where A is the heat source and k is the thermal conductivity. Given the boundary conditions:
	    i) $T = 0$ at the surface and
	    ii) Q is the heat flux at the surface,
	 which one of the following options would be the temperature (T) at depth z ?

(A)	$-\dfrac{(Az + 2Q)z}{2k}$
(B)	$-\dfrac{(Az + 2Q)z}{k}$
(C)	$-\dfrac{(Az + Q)z}{2k}$
(D)	$-\dfrac{(A + 2Q)z^2}{2k}$

Q.50	Consider a ray tomography experiment, where the goal is to estimate the wave velocity of 9 square cells plotted in each of the cases A and B. The ray paths for source-receiver pairs for both these cases are shown in the figure. Select the correct statement.
(A)	Both A and B are well-determined problems
(B)	Case A has a unique solution, and B is underdetermined
(C)	Both A and B are mixed determined problems
(D)	Case A is mixed determined, and B is underdetermined

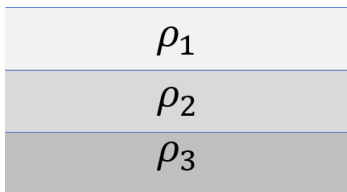| Q.51	Consider extracting the subsurface medium response by cross-correlating seismic ambient noise $u(t)$ and $v(t)$ measured at two stations. The cross-correlation $x(t) = \sum_\tau u(\tau)v(\tau + t)$ averaged over a period of one year is plotted in the figure, with most of the energy in the positive time lags. In this figure, four probable seismic sources are marked (i), (ii), (iii) and (iv). Assuming a homogeneous medium, select the source that is most probably excited.
(A)	(i)
(B)	(ii)
(C)	(iii)
(D)	(iv)

Q.52	Given the following electric field in cartesian coordinates $$\mathbf{E} = x^2 y\,\hat{\imath} + y^2 z\,\hat{\jmath} + z^2 x\,\widehat{\boldsymbol{k}},$$ which of the following statements is/are correct?
(A)	The electric field is not conservative
(B)	The electric field is static
(C)	Both divergence and curl of the electric field are zero
(D)	Electric field is neither conservative nor static

Q.53	What factor(s) determine(s) the magnitude of peak ground acceleration measured at a particular station due to an earthquake?
(A)	Distance from the earthquake
(B)	Rupture directivity
(C)	Origin time of the earthquake
(D)	Type of soil

Q.54	Consider a geophysical inverse problem of the form $d = Gm$, where G is the forward operator, m is the model vector and d is the observed data vector. The Earth model parameters can be estimated using $m^{est} = Hd$, where H is the pseudoinverse of G. Given $G = U\Sigma V^T$ as the singular value decomposition of G, and assuming G is full rank, which of the following options is/are correct?
(A)	$H = U^T\Sigma^{-1}V$
(B)	$H = V\Sigma^{-1}U^T$
(C)	$H = U^T\Sigma^{-1}V^T$
(D)	$H = UU^TV\Sigma^{-1}U^T$

Q.55	Consider ray tracing in an isotropic elastic Earth, with travel time function $T(x, y, z)$ in Cartesian coordinates. Select the correct option(s).
(A)	The slowness vector is tangential to the wave fronts
(B)	The slowness vector is parallel to the gradient of $T(x, y, z)$
(C)	$T(x, y, z)$ is constant on a particular wave front
(D)	$T(x, y, z)$ is constant along the rays

Q.56	Which of the following statements is/are correct regarding the properties of the oceanic lithosphere?
(A)	Older lithosphere cools at a slower rate compared to younger lithosphere
(B)	Heat flow increases with lithospheric age
(C)	Heat flow in the lithosphere increases with distance from the spreading ridge
(D)	Thickness of the lithosphere increases with age

Q.57	For a half space composed of 3 layers with resistivities ρ_1, ρ_2 and ρ_3, as shown in the figure, which of the following statements is/are correct about the variation of apparent resistivity with electrode spacing?
(A)	If $\rho_1 < \rho_2 < \rho_3$, the curve of apparent resistivity increases monotonically
(B)	If $\rho_1 < \rho_2 > \rho_3$, the curve of apparent resistivity decreases monotonically
(C)	If $\rho_1 > \rho_2 < \rho_3$, the curve of apparent resistivity first decreases and then increases
(D)	If $\rho_1 > \rho_2 > \rho_3$, the curve of apparent resistivity increases monotonically

Q.58	A loop of radius R carries a current I and produces a magnetic field **B**. Which of the following statements is/are correct about **B**?
(A)	The magnitude of **B** is directly proportional to I
(B)	The magnitude of **B** is inversely proportional to the square of radius R
(C)	The direction of **B** is perpendicular to the plane of the loop
(D)	The direction of **B** is parallel to the plane of the loop

Q.59	In seismology, Born approximation of the scattered (perturbed) wavefield is given by $$\delta u(\boldsymbol{r}, \boldsymbol{s}\,;t) \approx \int_V \delta r(\boldsymbol{x})(u_0(\boldsymbol{x}, \boldsymbol{s}\,;t) *_t u_0(\boldsymbol{r}, \boldsymbol{x}\,;t))\, d\boldsymbol{x}.$$ Here, • $*_t$ denotes temporal convolution • $\delta r(\boldsymbol{x})$ is the strength of the scatterer at $\boldsymbol{x}$ in volume V • $\delta u(\boldsymbol{r}, \boldsymbol{s}\,;t)$ is the scattered wavefield measured at the receiver $\boldsymbol{r}$ from the source $\boldsymbol{s}$ • $u_0(\boldsymbol{x}, \boldsymbol{s}\,;t)$ is the downgoing wavefield (to the scatterer at $\boldsymbol{x}$ from the source $\boldsymbol{s}$) in the unperturbed medium • $u_0(\boldsymbol{r}, \boldsymbol{x}\,;t)$ is the upgoing wavefield (to the receiver $\boldsymbol{r}$ from the scatterer at $\boldsymbol{x}$.) in the unperturbed medium Select the correct statement(s).
(A)	The Born approximation can be used to model multiply scattered waves
(B)	The Born approximation can model only first-order scattering
(C)	The scattered wavefield varies linearly with strength of the scatterers
(D)	The Born approximation can be used to model head waves from a horizontal reflector

| Q.60	A primary electromagnetic field (H_P) is being generated from current I_P flowing in a coil A with negligible capacitance, such that $H_P = KI_P \sin \omega t$, where ω is the angular frequency, K is a constant and t is time. A secondary electromagnetic field is being produced by induction in a conducting coil B. The phase difference between the primary and the secondary electromagnetic fields depends on which of the following factors?
(A)	Inductance of coil B
(B)	Resistance of coil B
(C)	Frequency of the primary electromagnetic field
(D)	Total current (I_P) flowing through the coil A

Q.61 Consider a medium of uniform resistivity with a pair of source and sink electrodes separated by a distance L, as shown in the figure. The fraction of the input current (I) that flows horizontally (I_x) across the median plane between depths $z_1 = \frac{L}{2}$ and $z_2 = \frac{L\sqrt{3}}{2}$, is given by $\frac{I_x}{I} = \frac{L}{\pi}\int_{Z_1}^{Z_2}\frac{dz}{\left(\frac{L^2}{4}+z^2\right)}$.

The value of $\frac{I_x}{I}$ is equal to _____

(*round off to two decimal places*)
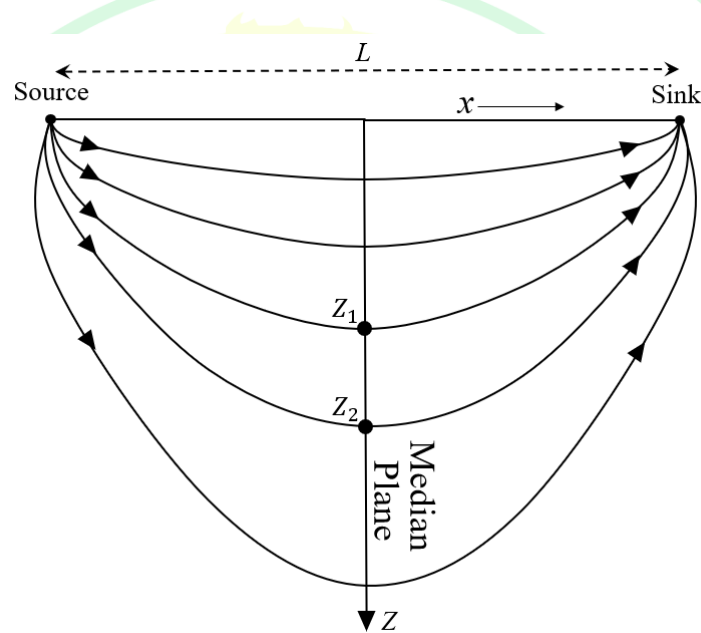
(*Figure not to scale*)

Q.62	Suppose a mountain at location A is in isostatic equilibrium with a column at location B, which is at sea-level, as shown in the figure. The height of the mountain is 4 km and the thickness of the crust at B is 1 km. Given the densities of crust and mantle are 2700 kg/m^3 and 3300 kg/m^3, respectively, the thickness of the mountain root (r1) is _____km.

(*Answer in integer*)

A

4 km

Crust

B

1 km

r1

Mantle
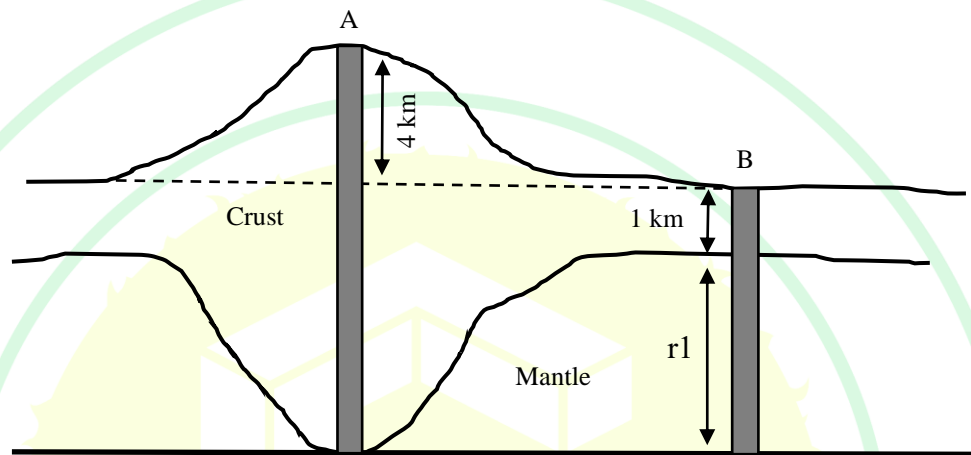
(*Figure not to scale*)
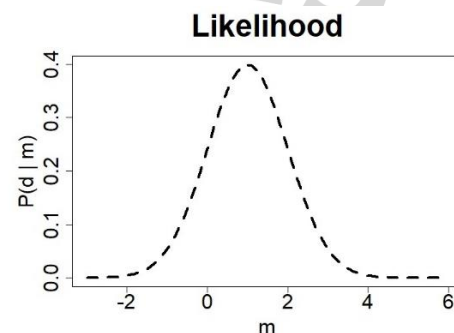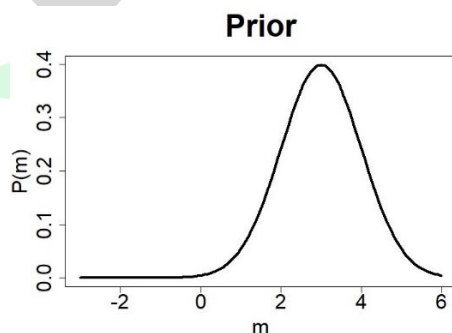
Q.63	While doing Bayesian inference, consider estimating the posterior distribution of the model parameter (m), given data (d). Assume that Prior and Likelihood are proportional to Gaussian functions given by

$$\text{Prior} \propto exp(-0.5(m-1)^2)$$
$$\text{Likelihood} \propto exp(-0.5(m-3)^2)$$

The mean of the posterior distribution is _____

(*Answer in integer*)

Q.64	Consider a two-dimensional reflection experiment, where a horizontal boundary between two layers is at a depth of 500 m below the free surface. A source and geophone are placed on the free surface with an offset of 2000 m. The P wave velocity of the top layer is 3000 m/s. The travel time of a recorded free-surface reflection multiple, which got reflected twice at the free surface, is _____ s. (*Round off to two decimal places*)

Q. 65	Consider the acceleration due to gravity (g') at an altitude (h) of 50 km above the Earth's surface. If R is the radius of the Earth, and the acceleration due to gravity measured at the surface is g, the ratio of g' to g, is _____ (*Assume $h<<R$, $R = 6370$ km, and round off to two decimal places*)