भू-विज्ञान परीक्षा
Geologist Examination 2014

A-FDN/RB-N-QZA

GEO-PHYSICS

Paper I

Time Allowed : Three Hours *Maximum Marks : 200*

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions :

There are NINE questions divided under TWO sections.

Candidate has to attempt ALL the NINE questions.

***ALL** the parts in the ONLY question in Section A are compulsory.*

In Section B, TWO parts out of THREE are to be attempted in each of the EIGHT questions.

The number of marks carried by a question/part is indicated against it.

All parts and sub-parts of a question are to be attempted together in the answer book.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the answer book must be clearly struck off.

Answers must be written in ENGLISH only.

Neat sketches are to be drawn to illustrate answers, wherever required.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

SECTION A

1. Attempt ***all*** of the following : *5×8=40*

(a) Show the ray geometry and names for the crustal P-phases. *5*

(b) The radius of the Earth is 6371 km. From Preliminary Reference Earth Model (PREM) rough estimate, how long does it take a P-wave to traverse the diameter of the Earth ? *5*

(c) Compare the least square for a 24-bit machine to 16-bit machine for measuring the variation of average Earth's magnetic field (assume 50,000 gammas). *5*

(d) Draw and discuss the variation of current lines in a homogeneous and anisotropic medium for a single source. *5*

(e) What is the physical significance of Green's function ?

Show that the function

$$\phi(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0} \int \frac{\rho(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} \, d\mathbf{r}'$$

satisfies the Poisson's equation for electrostatics :

$$\nabla^2 \phi(\mathbf{r}) = -\frac{\rho(\mathbf{r})}{\varepsilon_0}$$

and hence identify the corresponding Green's function. *5*

(f) Write down the mathematical forms of Maxwell – Boltzmann, Bose – Einstein and Fermi – Dirac distribution functions. Discuss under what condition both F-D as well as B-E distributions become equivalent to M-B distribution. *5*

(g) Using Gauss' theorem, obtain Poisson's equation for a scalar field. Under what condition does the above equation become identical to Laplace's equation ? *5*

(h) Calculate the maximum usable frequency for a transmitting station having a critical frequency of 13 MHz propagating with an angle of incidence of 60° for a given destination. *5*

SECTION B

2. Attempt any ***two*** of the following : *10×2=20*

(a) Illustrate in detail Airy's and Pratt's hypothesis of isostasy. Using Airy's hypothesis of isostasy, compute root for mountain and anti-root for ocean. *10*

(b) Show and discuss briefly the internal structure of the Earth using different criteria like mineralogical zones, seismological layers and dynamic layers. *10*

(c) What is the importance of seismic microzonation of a region ? How do you explain "site effects" ? Give two analytical techniques to compute site amplification factor for seismic events. *10*

3. Attempt any ***two*** of the following : *10×2=20*

(a) How does dilatancy model provide physical framework for precursory phenomena for intermediate-term and short-term earthquake prediction ? *10*

(b) What are different magnitude scales ? Give a brief description of each one. Why do all other magnitude scales saturate except M_w ? *10*

(c) What are secular and diurnal variations of geomagnetic field ? What causes the magnetic field to reverse its polarity and diurnal variation ? *10*

4. Attempt any ***two*** of the following : *10×2=20*

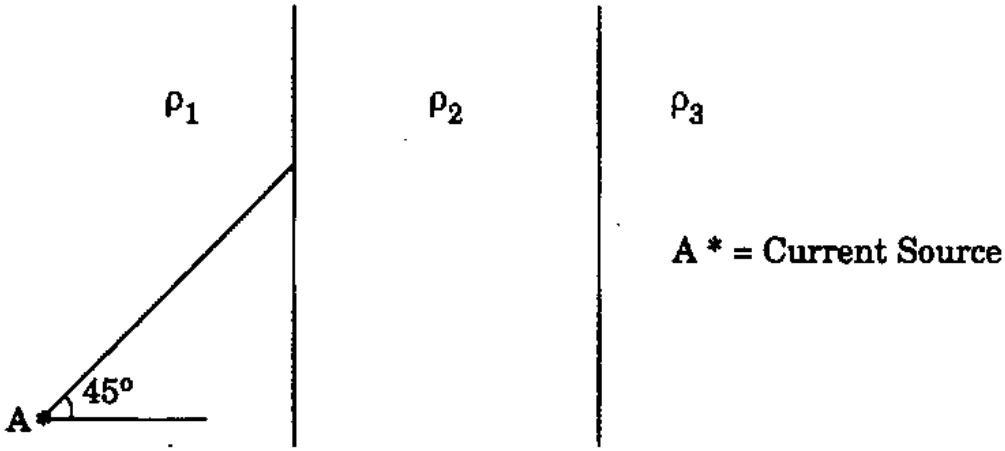
(a) A three layered apparent resistivity data was inverted and following were observed :

(i) The histograms of the second layer parameters are scattered.

(ii) There is a + 1 correlation between resistivity and thickness of second layer.

Discuss the above observations with respect to resolution and uncertainty analysis. *10*

(b) For the following situation :



(i) Calculate the angle at which the current enters the medium 3 from medium 2.

(ii) Comment on the bending of current lines in medium 2 as well as in medium 3. *10*

(c) (i) Define reflection coefficient. Obtain the extreme values of reflection coefficient.

(ii) Why, in general, is the vertical component of electric field not measured ? *10*

5. Attempt any ***two*** of the following : *10×2=20*

(a) In general, the em waves are elliptically polarized. Discuss the elliptically polarized em waves in a two-layered earth, where the first layer is highly conducting and the second layer is infinitely resistive. Both the layers are electrically homogeneous and isotropic. *10*

(b) (i) Draw and discuss the hypothetical Bouguer anomaly crossing over from continent to ocean.

(ii) Why must the normal component of the current density at the interface be the same ? *10*

(c) Compare the width of the gravity anomaly over a sphere and a cylinder with depth to their respective centres. *10*

6. Attempt any ***two*** of the following : *10×2=20*

(a) Consider two position vectors $\vec{A}$ and $\vec{B}$ with components

$$A_x = 6$$
$$A_y = 4$$
$$A_z = 3$$
$$\text{and } B_x = 2$$
$$B_y = -3$$
$$B_z = 2$$

Evaluate the scalar product $\vec{A} \cdot \vec{B}$ as well as the magnitudes $|\vec{A}|$ and $|\vec{B}|$ and obtain the angle between the two vectors. *10*

(b) Consider a mass 'm' oscillating under the influence of an ideal spring constant k, without friction, so that Newton's second law can be written as

$$m \frac{d^2 X(t)}{dt^2} + k X(t) = 0.$$

If X_0 is the position of the mass at t = 0, obtain its solution by the method of Laplace transformation. *10*

(c) In a rotation, in three dimensions, the square of the length of any position vector does not change. Using the matrix representation of such transformation, show that three independent angles are sufficient to describe such rotation. *10*

7. Attempt any ***two*** of the following : *10×2=20*

(a) A thermally insulated ideal gas is compressed from initial state with volume V_0 and pressure P_0 to a final state with volume V_f and pressure P_f. Show that the work done on the gas in the process is given by

$$W = \frac{C_v}{R} (P_f V_f - P_0 V_0)$$

where C_v and R have standard meanings. *10*

(b) What is a partition function ? Discuss its physical significance.

A system has only two available phase-space cells. The energies associated with the two cells are 0 and ε.

Obtain an expression for the partition function of the system as well as the fractional populations of the two cells. For $\varepsilon = k_B T = 1$ eV, what is the ratio of the populations of the two cells ? *10*

(c) Describe the phenomenon of Brownian motion and its relation to the random-walk problem. Introducing a thermal fluctuation, establish the differential equation for Brownian motion. *10*

8. Attempt any ***two*** of the following : *10×2=20*

(a) What is Faraday's law of electrolysis ? Express it mathematically.

A metal disk of radius a is rotating with an angular velocity ω with a magnetic field $\vec{B}$ applied vertically upwards. A circuit is made by connecting one end of a resistor of resistance R to an axle and the other end to a sliding contact that touches the outer edge of the metal disk. Find out the current induced in the resistor. *10*

(b) Write down the mathematical expression for Ampere's law as expressed in Maxwell's equations. Show that this equation is consistent with the continuity equation in electrodynamics for charged particles. *10*

(c) Define four-vectors A_μ, J_μ and ∂_μ for covariant description of Maxwell equation.

Use them to demonstrate that the Maxwell equations will have covariant form

$$\partial_\mu F^{\mu\nu} = J^\nu$$

in terms of electromagnetic field tensor

$$F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu$$ *10*

9. Attempt any ***two*** of the following : *10×2=20*

(a) Show mathematically that the phase velocity of an electromagnetic wave propagating in ionosphere is always greater than the velocity of light in free space. *10*

(b) For a half-wave dipole antenna, if the conductor diameter is about 95% of one-half of the free space wavelength of the propagating electromagnetic wave, show that the length of the antenna can be given by L = (142·5/f) metres with f in MHz. *10*

(c) What are the standard GPS satellite clocks and their orders of precision ? Show that the two standard carrier wave signals are generated at 1575·42 MHz and 1227·60 MHz. What is the role of these dual frequencies in GPS timing ? *10*