Serial No. | 0003522 | A-IGQ-O-IRC

# GEO-PHYSICS

## Paper—III

Time Allowed : Three Hours | Maximum Marks : 200

## INSTRUCTIONS

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

*There are ELEVEN questions divided under THREE sections.*

*Candidate has to attempt NINE questions in all.*

*The only question in Section A is compulsory.*

*In Section B, FOUR questions out of FIVE are to be attempted.*

*In Section C, FOUR questions out of FIVE are to be attempted.*

*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 other-wise mentioned, symbols and notations have their usual standard meanings.*

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

**Constants which may be needed :**

Kepler's Constant $3.986004418 \times 10^5 \ km^3 \ s^{-2}$

Mean radius of Earth $6378 \ km$

Mass of electron ($m_e$) $9.11 \times 10^{-31} \ kg$

Charge of electron (e) $1.602 \times 10^{-19} \ C$

Planck constant (h) $6.62 \times 10^{-34} \ J\text{-}sec$

Boltzmann constant (k) $1.38 \times 10^{-23} \ J/K$

## SECTION—A

1. Answer **ALL** of the following :                    $5 \times 8 = 40$

   (a)  (i)   State the reason(s) for opting for multi-channel recording of air-borne Induced Pulse Transient (INPUT) system in mineral surveys.                    2

   (ii)   State the three radioisotopes with sufficiently long half-lives whose decay produces an appreciable amount of gamma rays.                    .

   (iii)  State the reason for 'Herring Bone Effect' as seen on the aero-magnetic anomaly map.  2

   (b)  (i)   Write the main reason for the deployment of Ocean Bottom Cables (OBCs) in off-shore seismics.                    1

   (ii)   In an ocean bottom seismic survey, the depth to the first reflector is found to be 1000 m, the frequency of seismic wave was 100 hz. Find out the width of the first Fresnel zone.                    4

   (c)  Design a Wiener Inverse Filter, if the input signal is {5, 2, 1} and the desired output is {1, 0, 0}. Obtain the total least square error.                    5

   (d)  (i)   What is the wavelength range that corresponds to the band useful for the identification of rocks ?                    1

   (ii)   Explain the ground resolution distance (GRD) of panchromatic film.                    1

   (iii)  If the time interval between two photographs is 16 secs, and the speed of the aeroplane is 180 km/hr, then how many photographs would be required to complete a 1600 km × 1600 km survey area ?                    3

(e) What is single particle tunnelling ? Draw the current voltage characteristic for a tunnelling junction. 5

(f) For a rectangular cavity of length L and end square faces of length 2a, the components of wave vector

are $k_x = l \cdot \dfrac{\pi}{2a}$, $k_y = m\dfrac{\pi}{2a}$ and $k_z = n\dfrac{\pi}{L}$.

Find the frequency of oscillations of the field for a cavity of length 0.20 m and end square faces of length 0.02 m. Mode number along x –, y – and z directions are 0, 1 and $10^6$ respectively. 5

(g) Show that the Bohr's postulate about the angular momentum of an electron in a stationary state of an atom is consistent with de Broglie's wavelength. 5

(h) Determine the linear velocity of a satellite in geostationary earth orbit with radius r = 42,242 km. The earth rotates once per sidereal day of 23 hour, 56 minute, 4.09 sec. 5

## SECTION—B
(Attempt any **FOUR** questions)

2. (a) Explain the calibration of Natural Gamma Ray Spectrometer (NGS) logging tool with the help of necessary equations and a schematic diagram. Hence, indicate the method for assessing radioactive Uranium, Thorium and Potassium contents of a formation. 8+4

(b) Discuss in brief generation of International Geomagnetic Reference Field (IGRF) models used for processing of air-borne magnetic data. 6

(c) Indicate the two main reasons for not opting for air-borne gravity surveys in mineral and hydrocarbon exploration. 2

3. (a) Describe the construction and working principle of Graaf Sea Gravimeter with a schematic neat diagram. 4+4

(b) Why gyro-stabilized platform is used in carrying the marine gravity sensor ? 3

(c) Describe the working principle of hydrophone with a seritable schematic diagram. Discuss the technique of removing acceleration of hydrophones during survey. 10

4. (a) What are low-pass and high-pass filters ? Explain briefly with diagrams. 2

(b) Distinguish between pseudo-gravity and reduction to pole operations on the total magnetic field intensity data with suitable analytical expressions. 4+4

(c) What is z-transform ? Explain the z-transform for sample values of a wavelet taken at successive times. Can z-transform be used in the convolution and deconvolution operations ? Explain. 2+2+2

(d) Calculate the z-transform of a seismic time series :

$$b_t = (......, 0, 0, 1, 2, 0, -1, -1, 0, 0, .......).$$
4

5. (a) Discuss the various surficial indicators of possible mineralization which may be identified from photographs or imageries. 5

(b) Describe briefly the principle of air-borne flux-gate magnetometer. Explain the advantages of air-borne magnetic methods over the ground surveys.    7

(c) Discuss the essential elements of Geographic Information System (GIS). Also give the names of some remote sensing and GIS softwares which are in common use.    8

6. (a) Classify submarine sedimentation and stratigraphy. Discuss the occurrence of mineral deposits and hydrocarbon in off-shore.    5

(b) Plot the Fourier spectra for the following :    2×3

   (i) Box car function;

   (ii) Triangle function; and

   (iii) Ramp function.

(c) Define pixel and imagery. Derive the RADAR equation, and discuss the use of RADAR for the estimation of precipitation.    5

(d) State the two basic phenomena used in the construction of Alkali Vapour Magnetometer.    4

## SECTION—C

(Attempt any **FOUR** questions)

7. (a) Considering the influence of a magnetic field on the motion of an electron in an atom, explain Larmor precession and Larmor frequency and hence obtain susceptibility for a diamagnetic material.    10

(b) Considering the Hydrogen molecule interpret the molecular field between the electrons in terms of Heisenberg exchange interaction and explain the behaviour of exchange integral as a function of interatomic distance. 10

8. (a) (i) If absorption and spontaneous emissions were the only processes during the interaction of radiation with matter, show that variation of energy density, $u(w)$ with temperature is not in accordance with Planck's law i.e.

$$u(w) = \frac{A_{21}}{B_{12}} \left[ e^{\hbar w/kT} - 1 \right]^{-1} ;$$ A and B are

Einstein's coefficients.

(ii) What arguments Einstein gave to bring the compatibility between the two ?

(iii) On the basis of his arguments, obtain the relation for $u(w)$. 10

(b) For a four-level laser, just below threshold for laser oscillations,

$$\frac{N_3 - N_2}{N_0} \cong \frac{W_p}{W_p + S_{32}} .$$
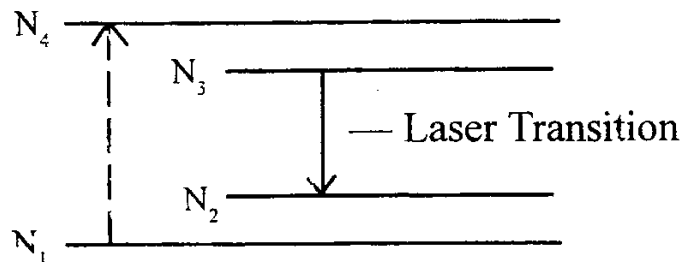


$W_p$ is pumping speed and S stands for spontaneous emission rate.

Using the given data, find threshold pumping rate and finally the power required for the oscillations.

$N_1 = 6 \times 10^{19}$ cm$^{-3}$, $\Delta N$ (population inversion) = $4 \times 10^{15}$ cm$^{-3}$

$T_{sp} = 2.3 \times 10^{-4}$ s, $v_p = 4 \times 10^{14}$ Hz and

$N_0 = N_1 + N_2 + N_3 + N_4.$ ⟶ 10

9. A negative feedback circuit with two amplifiers and gains $A_1$ and $A_2$ is shown below.

   (a) Determine the feedback factor $\beta$ to obtain closed loop gain $A_f = 40$. ⟶ 2

   (b) To evaluate the stability of this circuit, determine the percentage change in closed loop gain for 10% decrease in gain $A_1$. You may use the value of $\beta$ obtained in (a). ⟶ 3
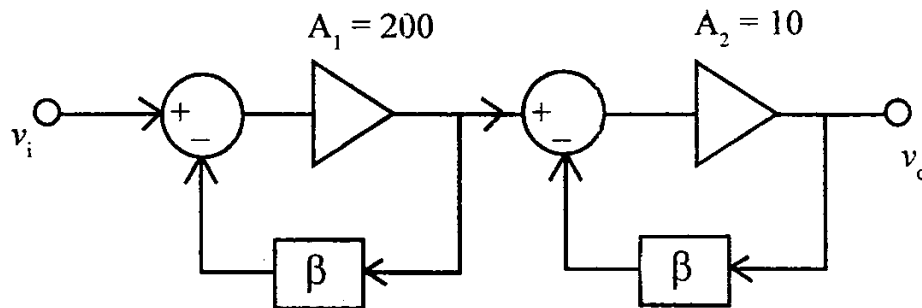


10. (a) Describe the various radar techniques to acquire and track a target in sky. What are the requirements of a radar antenna if it is to acquire and track a fast moving military aircraft ? ⟶ 6+8

(b) A target in sky is located at a distance of 2 km from the radar, and can be modeled as a circular metallic object of radius 100 m. Determine the beam shape and beam width of radar antenna consistent with this target. 6

11. (a) Show that the eigen functions of an Hermitian operator are orthogonal. 10

(b) Consider a system described by a normalized wave function $| \psi >$, show that result of a measuring quantity F is given by

$$< F > = < \psi | F | \psi > = \sum_m \sum_n C_m^* C_n < W_m | F | W_n >$$

$$= \sum_n \lambda_n | C_n |^2$$

where $C_n$ are real, imaginary or complex expansion coefficients. $\lambda_n$ are eigen values corresponding to eigen functions $W_n$. 10