Open University of Sri Lanka
B.Sc. Degree Programme (Level – 05)
PHU5308 – Fundamentals of Geophysics
Final Examination 2024/25

Date: 27th May 2025 Time Allowed: 2 hours (9.30-11.30)

The paper consists of ***Six (06)*** questions. Answer ***Four (04)*** questions only. Answers should be illustrated with sketch maps and diagrams where appropriate. Each question carries equal marks.

1 a From basic principles, show that the travel time equation used in refraction seismic Survey for a horizontal, planar and homogeneous two-layer case is given by (8 marks)

$$t_x = \frac{x}{v_2} + \frac{2h\sqrt{v_2^2 - v_1^2}}{v_1 v_2}$$

b The following dataset was obtained from a reversed seismic refraction profile 62.5m long. The survey was carried out on level ground to determine the nature of subsurface layering. Assuming homogeneous and planar layers, carry out a graphical interpretation of the data and summarise your results using an annotated cross-section. (17 marks)

Forward direction:		Reverse direction:	
Offset (m)	Travel time (ms)	Offset (m)	Travel time (ms)
0.0	0.0	0.0	22.1
10.0	5.0	10.0	19.2
20.0	10.0	20.0	16.4
30.0	15.0	30.0	13.6
40.0	17.3	40.0	10.7
50.0	19.4	50.0	6.3
60.0	21.6	60.0	1.3
62.5	22.1	62.5	0.0

2 (a) How do you determine the earthquake epicenter from seismic waves? Give its mathematical expression. *(5 marks)*

(b) Three seismometers (S_1, S_2, and S_3) are located at the longitudes and latitudes shown in the table below. They first measure P- and S –waves due to nearby nuclear explosion at times indicated in the table. The explosion occurs on the surface. Assume that local P-wave and S-wave velocities are α =6.2 kms^{-1} and β = 4.1kms^{-1} respectively.

	S1	S2	S3
Latitude	43° N	40° N	40° N
Longitude	100° W	100° W	104° W
First P-wave	13 h 22 m 57.7 s	13 hr 23 m 4.7 s	13 hr 22 m 40.1 s
First S-wave	13 h 23 m 25.8 s	13 hr 23 m 37.8 s	13 hr 23 m 1.7 s

(i) Calculate the distance from the nuclear explosion site to each of the seismometer *(8 marks)*

(ii) Estimate the epicenter of the explosion (it lies within the region 40°-43° N and 100°-104° W). Use graph sheet to illustrate the location of epicenter *(12 marks)*
(assumption: Earth radius is 6280 km and Earth is a spheroidal body)

3. (a) Discuss the advantages and disadvantages of aeromagnetic surveying. *(5 points)*

(b) How and why do the methods of reduction of gravity and magnetic data differ? *(5 points)*

(c) Compare and contrast the techniques of interpretation of gravity and magnetic anomalies. *(5 points)*

(d) Assuming the magnetic moment of the Earth is $8 \times 10^{22} Am^2$, its radius as 6370 km and that its magnetic field conforms to an axial dipole model, calculate the geomagnetic elements at 60°N and 75°S. *(10 points)*

4. (a) What are the minerals that can be used for radiometric survey? *(5 points)*

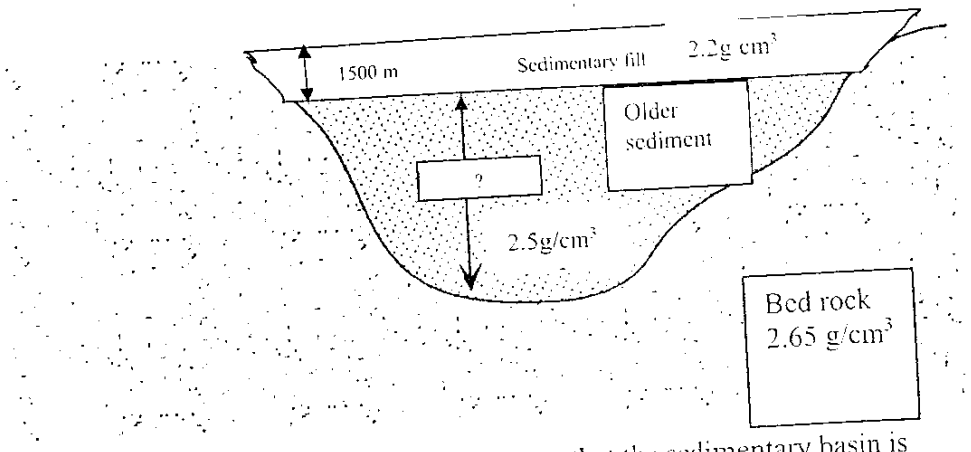
(b) How many half-lives must elapse before the activity of a radioactive isotope decreases to 1% of its initial value? How long is this time for 14C, which has a decay rate of 1.21×10^{-4} yr^{-1}? *(10 points)*

(a) Radiocarbon dating of a sample of wood from the tomb of an Egyptian pharaoh gave isotopic concentrations of 9.843×10^{-15} mol g^{-1} for ^{14}C and 1.202×10^{-2} mol g^{-1} for ^{12}C. Assuming that the initial $^{14}C/^{12}C$ ratio in the sample corresponded to the long term atmospheric ratio of 1.20×10^{-12}, determine the age of the tomb, the percentage of ^{14}C remaining, and the original ^{14}C concentration in the wood.

(10 points)

5. The sedimentary fill shown in the following diagram is known to consist of young flat lying sediments of density 2.2 g/cm^3 to depth of 1500 m followed by an unknown thickness of older sediments of density 2.5 g/cm^3 and overlying bed rock of 2.65 g/cm^3.

1 *Gal* $= 10^{-2}$ m/s^2 ; Gravity effect of horizontal cylinder $g = 2\pi G\rho z$:
uniform density = ρ: thickness = z;
G = Universal Gravitational Constant = 6.67×10^{-11} Nm^2/Kg^2



a Calculate the Δg for sedimentary fill (Assume that the sedimentary basin is modelled as a horizontal cylinder). (5 marks)

b Assuming the total gravity anomaly observed in the sedimentary basin from the bed rock is 40 mGal, Calculate the Δg of the second layer (5 marks)

c What is the maximum thickness of the older sediments? (5 marks)

d Calculate the depth of the sink of continent. in case of adding a 2 km thick glacier on top of a continent. See the diagram below. (10 marks)

(a) block *A*

material	density	thickness
air		z_0
sediments	2.0 Mg m^3	3 km
crust	2.7 Mg m^3	30 km
mantle	3.1 Mg m^3	70 km
lower level	3.2 Mg m^3	z_a

(b) block *B*

material	density	thickness
ice	0.9 Mg m^3	2 km
sediments	2.0 Mg m^3	3 km
crust	2.7 Mg m^3	30 km
mantle	3.1 Mg m^3	70 km
asthenosphere		

6. A vertical electricity survey (VES) was carried out in Keenagoda Village, Monaragla District, to find out the subsurface condition of a location for the purpose of groundwater abstraction. The VES was performed using Schlumberger array at a point 'P' (center point). The distance from 'P' to any current electrode (AB/2) and the distance from 'P' to any potential electrode (MN/2) are given in the table below. (The geometric constant for the Schlumberger array is given as, $K = \frac{\pi(AB^2 - MN^2)}{4MN}$

AB/2 (m)	MN/2 (m)	K (m)	R(Ω)	ρ(Ωm)
1.5	0.5		92.70	
2	0.5		49.36	
3	0.5		20.36	
4.5	0.5		7.30	
6	0.5		3.43	
8	0.5		1.75	
10	0.5		0.99	
12.5	0.5		0.59	
10	2		3.86	
12.5	2		2.24	
15	2		1.55	

20	2		0.86	
25	2		0.60	
30	2		0.47	
25	5		1.45	
30	5		1.09	
35	5		0.92	
40	5		0.79	
50	5		0.53	

(a) Calculate the geometric constant (K) and apparent resistivity values (ρ) for each electrode separation and construct the resistivity curve in the given graph sheet. *(15 marks)*

(b) Using the constructed curve answer the following questions *(10 marks)*

a. What is the type of the curve?
b. How many subsurface layers can you identified?
c. What is the qualitative interpretation of resistivity of each layers that you have identified?
d. How many subsurface layers can you identified?
e. What is the qualitative interpretation of resistivity of each layers that you have identified? (Detach the page no 6 and attached to the answer script if you answer for question no. 6)