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THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

B.Sc. DEGREE PROGRAMME- LEVEL 05 - 2016/17
PYU3168 – FUNDAMENTALS OF GEOPHYSICS
FINAL EXAMINATION

DATE: 8th January 2018 **DURATION: TWO HOURS**
TIME: 9.30 am. – 11.30 am

INDEX NO: .....

IMPORTANT INSTRUCTIONS TO CANDIDATES

- THIS QUESTION PAPER CONSISTS OF 08 PAGES WITH SIX (06) ESSAY TYPE QUESTIONS.
- WRITE YOUR INDEX NUMBER IN THE SPACE PROVIDED. (UNDER PROTEST CANDIDATES MUST WRITE THEIR REGISTRATIOS NUMBER INSTEAD)
- ANSWER **FOUR (04) QUESTIONS**.
- ALL ANSWERS MUST BE WRITTEN IN THE SEPARATE ANSWER SHEETS. SHORT ANSWERS ARE PREFERRED.
- ANSWERS SHOULD BE ILLUSTRATED WITH SKETCH MAPS AND DIAGRAMS WHERE APPROPRIATE.
- MARKS ALLOCATED FOR EACH PART OF THE QUESTION ARE GIVEN IN BRACKETS.
- NON-PROGRAMMABLE CALCULATORS ARE PERMITTED.
- GRAPH SHEETS AND LOG-LOG SHEETS ARE PROVIDED UP ON REQUEST.

1 a From first principles, show that the travel time equation used in refraction seismology 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 Define focus and epicenter of an earthquake. (5 marks)

b How do you determine the earthquake epicenter from seismic waves? (7 marks)

c 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. (13 marks)

	S1	S2	S3
Latitude	43° N	40° N	40° N
Longitude	100° W	100° W	104° W
First P-wave	13h 22m 56.7s	13hr 23m 4.7s	13hr 22m 40.1s
First S-wave	13h 23m 25.8s	13hr 23m 37.8s	13hr 23m 1.7s

(i) Calculate the distance from the nuclear explosion site to each of the seismometers.

(ii) Estimate the epicenter of the explosion (it lies within the region 40°-43° N and 100°-104° W).

3 a Differentiate seismic refraction and reflection surveys (5 marks)

b Derive travel-time equation of reflected seismic wave arrivals (two-layer case, horizontal interface): (8 marks)

$$T(x) = \sqrt{\left(X/V_1\right)^2 + \left(2d/V_1\right)^2}$$

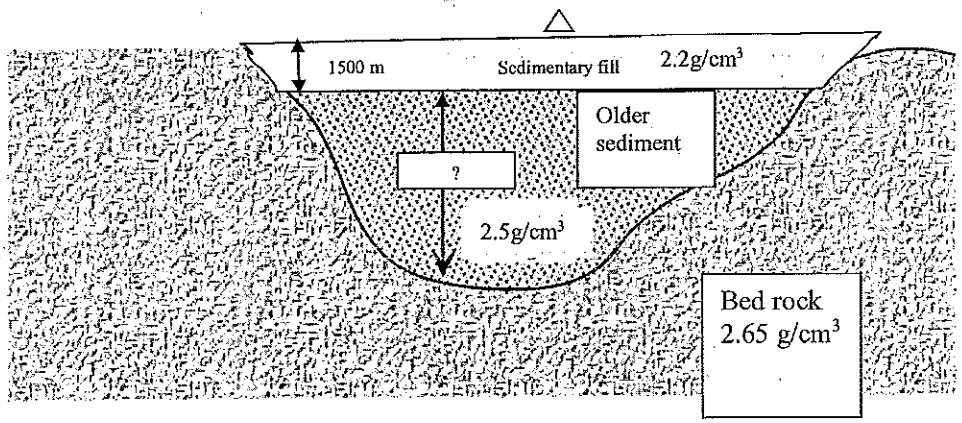
c Suppose that seismic reflection survey was done over layered sequence shown in the following figure where interval velocities and layer thicknesses are given. Determine the average and root mean square velocities as function of zero offset reflection time. (12 marks)

v1 = 1000 m/s	50 m
v2 = 2500 m/s	100 m
v3 = 1500 m/s	75 m
v4 = 3000 m/s	150 m
v5 = 4000 m/s	

4 a What is a Bouguer anomaly used in gravity method? (5 marks)

b 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. (5 marks)

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 x 10^{-11} Nm^2/Kg^2
Calculate the Δg for sedimentary fill (Assume that the sedimentary basin is modelled as a horizontal cylinder).

c Assuming the total gravity anomaly observed in the sedimentary basin from the bed rock is 40 mGal, Calculate the Δg of the second layer (10 marks)

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

5 a The data were collected by a gravimeter with dial constant of 0.0869 mgals/dial division. Assume that the base station value of g is 0 milliGals, so all corrections will be relative to 0. (20 marks)

Station	Time	Reading in dial divisions
Base	11:20	762.71
GN1	11:42	774.16
GN2	12:14	759.72
GN3	12:37	768.95
GN4	12:59	771.02
Base	13:10	761.18

Use the following equation for the calculations of instrument drift and tidal corrections.

$$OG3 = (OG5 - OG1)\frac{(T3 - T1)}{(T5 - T1)} + OG1$$

where G is observed gravity and T = time

Complete the table below.

	time	dial reading	Converted to milliGals	relative difference	Tide & Drift	Drift corrected
Base Station	0	762.71	66.279499	0	0	0
1	22	774.16				
2	54	759.72				
3	77	768.95	66.821755	0.542256	-0.09307	0.635326
4	99	771.01				
Base Station	110	761.18	66.146542	-0.132957	-0.13296	0

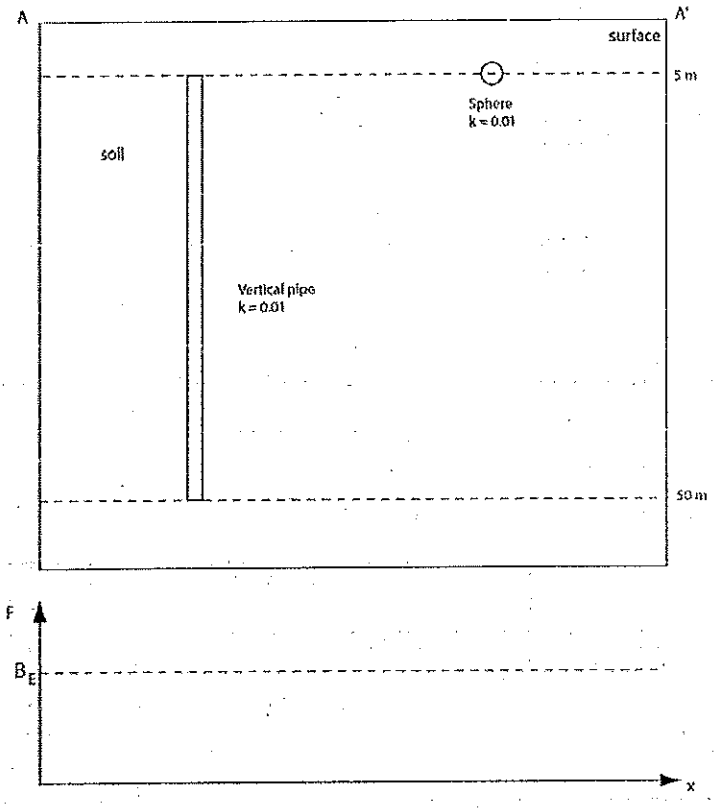
b Is there any gravity anomalies observed in these sites? (5 marks)

6. (a) Sketch the total magnetic field anomaly observed along the profile A-A'(given in page 10) for a survey at the North Magnetic Pole. Estimate the relative half width of the magnetic anomalies. *(10 marks)*

(b) Repeat for a magnetic survey at the Magnetic Equator where the direction AA' is parallel to magnetic North. *(5 marks)*

(c) Draw a map of the total magnetic field anomaly around the pipe and sphere for each case (a) and (b). *(5 marks)*

(d) Explain how a rock develops detrital remnant magnetization *(5 marks)*


A
A'
surface
5 m
Sphere
k = 0.01
soil
Vertical pipe
k = 0.01
50 m
F
B_E
x