NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

MAPH 5237 – GEOELECTRIC AND EM METHODS

MSc PART 1: MAY 2006 DURATION: 4 HOURS

ANSWER **ALL** QUESTIONS.

1. (i) The resistance for an ordinary wire is given by Ohm's law, V = IR.
Show that the resistivity of a cylindrical conductor of cross-sectional area A, and length L is given by $\rho = R\left(\frac{A}{L}\right)$ [6]

(ii) Illustrate how Ohm's law can be expressed in terms of Electric field strength, E. [3]

(iii) Relate the electronic and electrolytic conduction methods to Induced Polarisation. [6]

2. A former landfill is now undeveloped wasteland. It is suspected that a leachate plume is escaping from the landfill.

Critically assess which geophysical methods should be used to investigate the environmental issue. Include in your answer surveying techniques and the qualitative interpretation of the results. [10]

3.

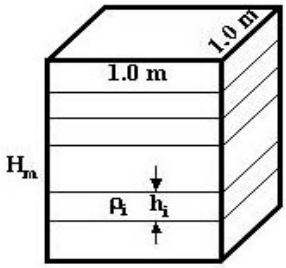

Figure 1.

In the figure above, the layers are of equal thickness, (h_i = 5m). Resistivity at the surface layer is 10Ωm and increases in every layer by 20Ωm. The longitudinal resistivity is given by, $\rho_l = \dfrac{\sum h_i}{\sum \dfrac{h_i}{\rho_i}}$ and the transverse resistivity is $\rho_t = \dfrac{\sum \rho_i h_i}{\sum h_i}$

Is the material in above figure anisotropic or isotropic? Determine the coefficient of anisotropy in answering the question. [5]

4. (a) Explain how pressure and temperature affect resistivity in ionic conduction. [4]

(b) Explain the significance of the following expression in determining apparent chargeability; $\dfrac{\eta_a}{\eta_1} = 1 + \sum_{i=2}^{n} \dfrac{\partial \log \rho_a}{\partial \log \rho_i}\left[\dfrac{\eta_i}{\eta_1} - 1\right]$ [4]

5. (a) Given that the double dipole method is used in an IP survey, what is the depth of exploration for the conditions a = 2m and n = 5? [6]

(b) In the self potential exploration method, how does the leap-frog technique reduce polarisation effects? Give and explain any two of its advantages? [5]

(c) Explain how non – uniqueness affects the resistivity exploration method and how its effect can be reduced. [4]

6. In the electromagnetic exploration method, explain the role that Faraday's Law of induction plays. Thus show and explain the meaning of the following expression:

$$-\frac{\partial \Phi}{\partial t} + IR + L\frac{\partial I}{\partial t} = \mathbf{0} \qquad [8]$$

7.

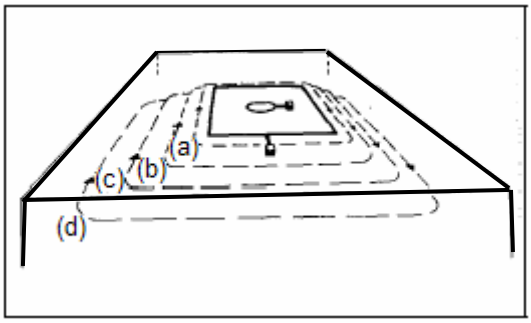

Figure 2.

(a) The figure above illustrates the Time Domain Electromagnetic surveying technique. Explain the nature and origin of the successive loops, (a) to (d). [5]

(b) In the Frequency Domain Electromagnetic surveying technique, the magnetic field in the conductor experiences a phase shift due to the conductivity. Explain. [5]

8. (i) Explain why three components of the magnetic field are measured in a magnetotelluric (MT) sounding. [3]

(ii) Given that $E_x = -\frac{\mathbf{1}}{\mu_0 \sigma}\frac{\partial B_y}{\partial z}$ and $B_y(z,t) = B_0 e^{-z/d}\cos\left(\omega t - \frac{z}{d}\right)$

Show that $E_x = \frac{B_0}{\mu_0 \sigma d} e^{-z/d}\sqrt{\mathbf{2}}\cos\left(\omega t - \frac{z}{d} + \frac{\pi}{\mathbf{4}}\right)$ [4]

9. (i) Ground Penetrating Radar (GPR) makes use of the 'echo principle' Explain [4]

(ii) "The GPR method is effective in mapping near surface objects". Justify the statement. [4]

(iii) In a Very Low Frequency method interpretation, explain how depth of investigation is determined. [4]

10. Plot and interpret the Vertical Electric Sounding results shown in the table below.

$\frac{AB}{2}$ (m)	**VES 1** (Ωm)	**VES 2** (Ωm)
1.8	58.1	54.6
2.5	62.6	58.4
3.5	57.8	63.4
5	56.3	63.5
7	55.9	58.5
10	68.2	67.5
13	79.7	63.2
18	81.9	80.9
25	76.3	114.1
35	85.6	162.9
50	106.1	234.8
70	134.8	314.1

[10]

THE END