Geophysics 424 Mid-term exam
Tuesday October 21st 2009

Name _____

Student number _____

*Time allowed : **50 minutes**.*

*Attempt all **FIVE** questions*

Note the number of points allocated for each part.

Calculators and rulers may be used

Notes and textbooks may not be used during the exam.

Please hand in this exam, with your name and student number listed above

Total points for whole exam = 50

Question 1 – Resistivity of rocks (Total = 9 points)

The pore space of a sandstone is 50% saturated with salt water
The salt water has a salinity of 10g per litre
The rock has isolated pores and a bulk resistivity of 50 Ωm
The rock grains have a resistivity of 2000 Ωm

(a) What is the porosity of the sandstone ? **(5 points)**

(b) State two assumptions that you have made in answering (a) **(4 points)**

Question 2 : Maxwell's equations (Total = 16 points)

Low frequency electromagnetic (EM) fields propagate in the Earth and the **displacement current** can be ignored.

The z-axis is oriented vertically downwards
The x-axis and y-axis are horizontal and mutually orthogonal.

The EM fields vary harmonically with time as $e^{-i\omega t}$ at an angular frequency ω

(a) Expand Ampere's Law and Faradays Law to give **six equations** for the components of **E** and **B**.

(6 points)

(b) These electromagnetic fields propagate in the Earth in a region where the conductivity **does not vary** in the x-direction.

Show that the **six equations** in (a) can be separated in two sets of 3 equations.

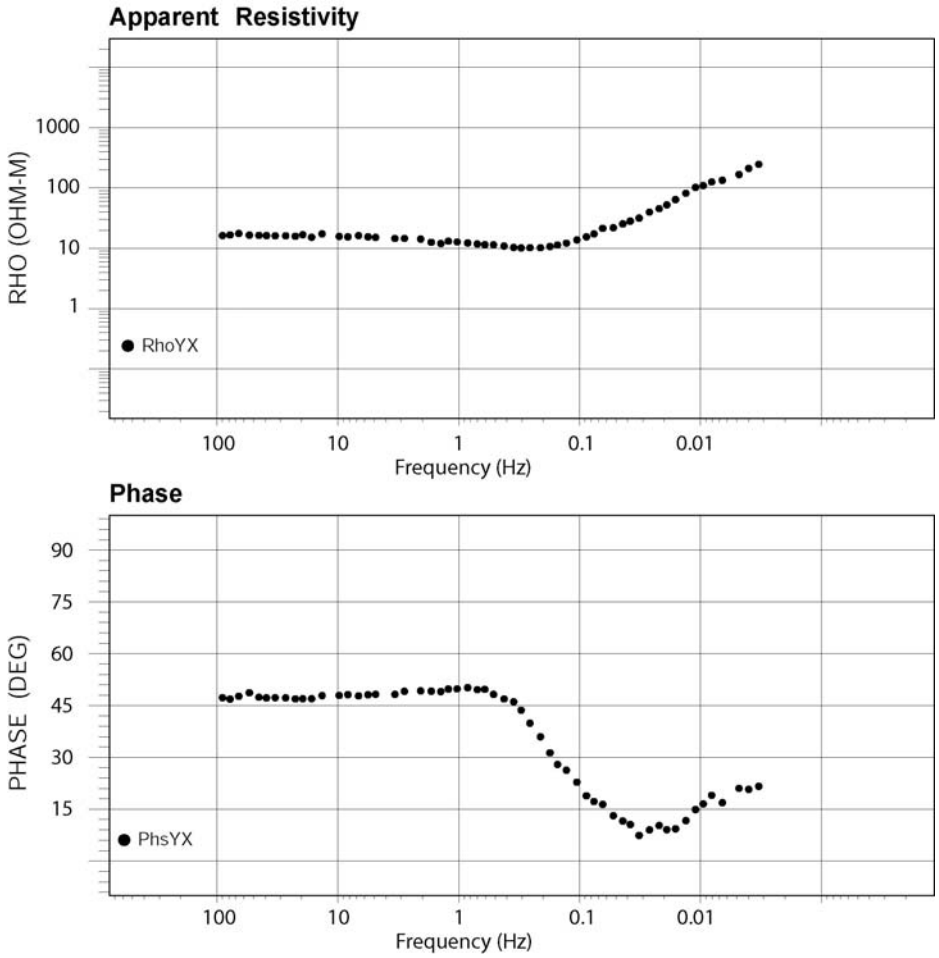
(4 points)

(c) Select the 3 equations that include E_x and derive a second order differential equation for E_x

(4 points)

(d) Which magnetotelluric mode does this represent? **(2 points)**

Question 3 : Magnetotellurics (Total = 12 points)



The figure above shows MT data recorded in the Western Canada Sedimentary Basin. The data can be interpreted in terms of a **2 layer resistivity model**.

In (a)-(d), explain how you derived your answer.

(a) What **total recording time** and **sample rate** are needed to obtain these MT data? **(4 points)**

(b) Estimate the **resistivity** of the **upper layer**? **(2 points)**

(c) Estimate the **thickness** of the **upper layer**? **(3 points)**

(d) Estimate the **resistivity** of the **lower layer**? **(3 points)**

Question 4 : EM34 (Total = 9 points)

(a) An EM34 instrument has a TX-RX separation of 10 m, and uses a frequency of 6400 Hz. TX and RX dipoles are oriented **vertically**.

A survey begins in a region where there is a thick surface clay layer (ρ = 25 Ωm)

Prove that this corresponds to a **low induction number**. **(3 points)**

(b) The EM34 survey encounters a region where the clay layer is only 5 m thick and overlies crystalline basement rocks (ρ = 1000 Ωm).

What value of **apparent resistivity** will be measured? **(4 points)**

(c) Will the apparent resistivity be **higher or lower** if horizontal dipoles are used? Just give a qualitative answer. **(2 point)**

Question 5 : Magetotellurics (Total = 4 points)

An MT instrument malfunctions and only records data at frequency of 0.1 Hz

At one location, the apparent resistivity was 240 Ωm and the phase angle is 54°

Determine **as much as possible** about the resistivity structure from these data.