Geophysics 424 Mid-term exam
Wednesday October 15, 2014

Name _____

Student number _____

Time allowed : ***55 minutes***.

Attempt all ***FOUR*** *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

Explain your answers

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

Total points for whole exam = 45

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

The pore space of an isotropic sandstone is 80% saturated with salt water
The salt water has a salinity of 20 g per litre
The rock has isolated pores and a bulk resistivity of 50 Ωm
The rock grains have a resistivity of 2000 Ωm

(1a) What is the resistivity of the salt water? **(2 points)**

(1b) What is the porosity of the sandstone? **(3 points)**

(1c) State two assumptions that you have made in answering (1b) **(4 points)**

Question 2 : Maxwell's equations (Total = 14 points)

A **plane** EM wave with frequency, f, is travelling **vertically** downwards in the Earth in the *z*-direction. The conductivity of the Earth is σ
The wave has an angular frequency, ω, and varies with time (t) as $e^{-i\omega t}$
The electric field is **polarized** in the x-direction
It can be shown that Maxwell's equations reduce to a single differential equation for E_x

$$\frac{\partial^2 E_x}{\partial z^2} + i\omega\mu\sigma E_x = 0$$

(2a) Find a solution to this equation of the form $E_x = Ae^{kz}$
The EM signal has amplitude $E_x = E_o$ at $z = 0$ m
Derive values for A and k. Explain your method clearly.

(6 points)

(2b) Give a definition of the skin depth (δ) and show that

$$\delta \sim \frac{503}{\sqrt{\sigma f}} \text{ (m)}$$ **(5 points)**

(2c) Sketch the variation of the real part of $E_x(z)$ **(3 points)**

Question 3 : Magnetotellurics (Total = 11 points)

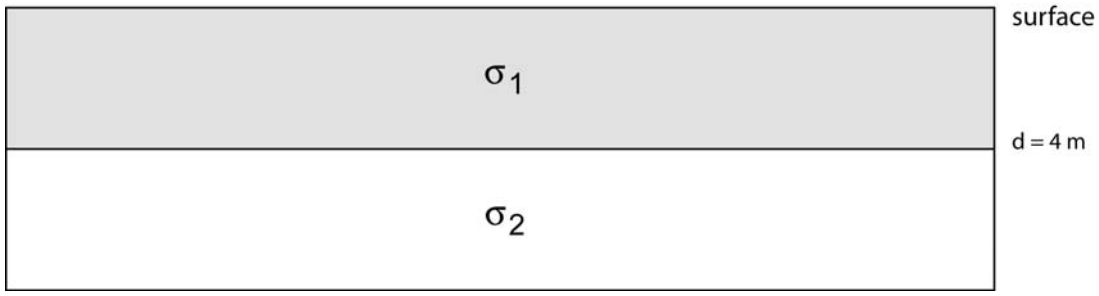
(3a) You are collecting MT data in Antarctica where the geomagnetic field is **vertical** and has a value of 60,000 nT

A magnetic fluxgate sensor is buried **horizontally** in the ice and oscillates at a frequency of 0.1 Hz, with an amplitude of +/- 2° from the horizontal.
What **magnetic noise level** will result from this motion? **(4 points)**

(3b) Name the two sources of MT signals, and approximate frequencies **(4 points)**

(3c)What is the relationship between apparent resistivity and phase in magnetotellurics? **(3 points)**

Question 4 : Frequency domain EM (Total = 11 points)



A frequency domain EM system has a frequency of 500 Hz and transmitter-receiver (TX-RX) distance of s = 8 m.

All measurements are made with TX and RX on the surface

(4a) Over what range of Earth conductivity values would this system be operating in the near field? **(3 points)**

(4b) The EM system is used to investigate a 2 layer Earth. An excavation showed that the interface between the layers was at a depth of 4 m. The instrument measures apparent conductivities of 0.05 S/m in vertical dipole mode and 0.07 S/m in horizontal dipole mode.

Calculate σ_1 and σ_2 **(6 points)**

(4c) Why is relative motion of the TX and RX a problem in this type of survey **(2 points)**