Geophysics 210 - Physics of the Earth

Final exam

Section	GEOPH 210 Lecture A01
Instructor	Dr. Martyn Unsworth
Date	Friday December 12th 2008
Time allowed	9:00 a.m. – noon

Total = 104 points

*Please attempt **ALL** FOUR questions.*

*Notes and books may **NOT** be used during the exam.*

Calculators are permitted.

Show all working, as credit will be given for your method as well as the final answer.

All questions should be directed to the invigilator.

Please hand in this exam, with your answer booklet.

Name _____

Question 1 – Short answers

(a) Name the two types of **surface wave**. Sketch the **particle motion** for each wave.
(6 points)

(b) List **three factors** that cause the acceleration of gravity (**g**) to vary from the North Pole to the Equator.

For each factor, state if **g** is greatest at the North Pole or the Equator
(6 points)

(c) What two important **mineral transitions** occur in the mantle over the depth range of 200-700 km? Give approximate depths for both.
(6 points)

(d) Briefly explain the concept of **isostatic rebound**, and name two locations where it can be observed at present. **(5 points)**

(e) What is the **Chandler wobble**? What is the energy source that causes it?
(4 points)

(f) What is the **Curie depth**? **(3 points)**

(g) Give an approximate age for the **last geomagnetic reversal**? **(2 points)**

(h) State one piece of evidence that indicates that we might be **approaching** another geomagnetic reversal.
(2 points)

(Q1 Total = 34 points)

Question 2 – Earthquake seismology

(a) An earthquake on a thrust fault ruptures with an offset of 2 m.

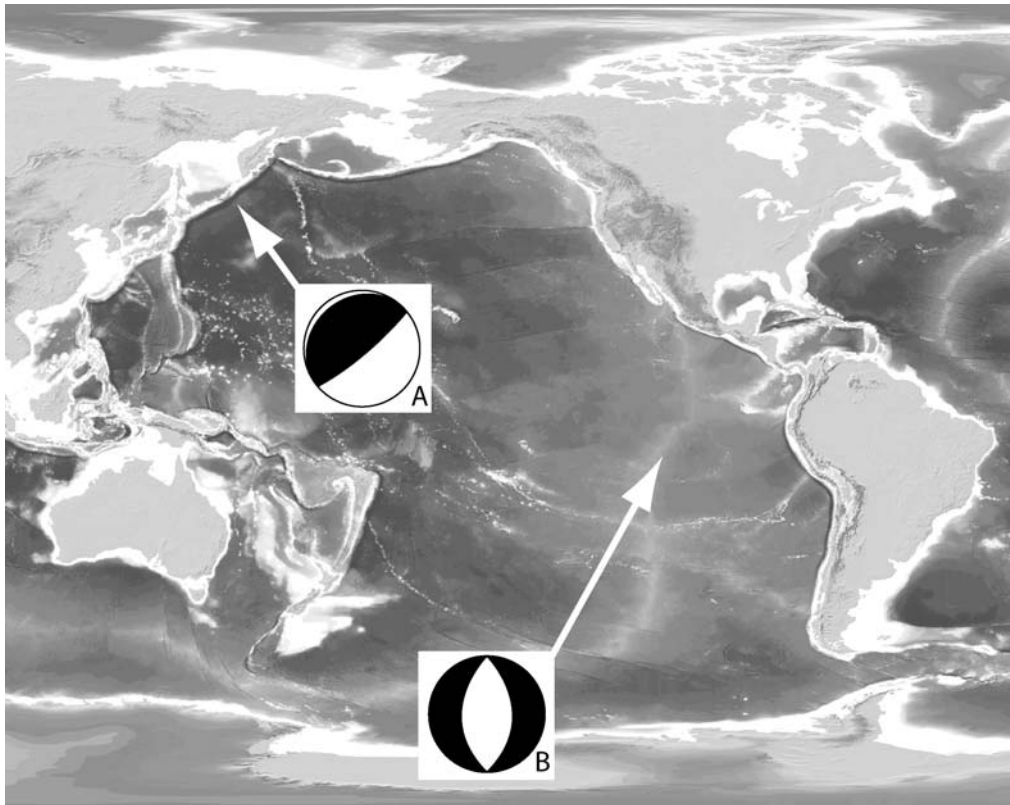The fault plane was 200 km by 30 km.

The shear modulus of the crust at this location is 100 GPa.

What is the **moment magnitude** of the earthquake? **(3 points)**

(b) Two earthquake focal mechanisms are shown below (A and B)

For each, name the type of fault that caused the earthquake.

Explain how is each earthquake is related to its location. **(7 points)**

(c) Draw a sketch map showing a **transform fault** on a mid-ocean ridge.

Sketch the **focal mechanism** of an earthquake on the transform fault.

How did this focal mechanism give **evidence** for seafloor spreading? **(6 points)**

(Q2 Total = 16 points)

Question 3 – Global Seismology

Sketch raypaths and travel times on the figure on page 5

An earthquake occurred at 'E' on a planet. It was measured by 12 seismic stations shown by on page 5. The planetary radius is R = 4000 km

Δ is the angular distance from E to the seismic station.

The mantle has a **uniform** P-wave velocity (v_m)

The core has a **uniform** P-wave velocity (v_c)　　　　　　　$v_c < v_m$

P (Direct P-wave)

(a) Show that the travel time for the direct P-wave is given by

$$t = \frac{2R\sin(\Delta/2)}{v_m}$$　　　　　**(3 points)**

(b) Sketch the raypaths for the direct P-wave for each station at which it is observed. Use the figure on page 5　　　　　**(2 points)**

(c) Compute the mantle velocity (v_m) from the travel times.　　　**(2 points)**

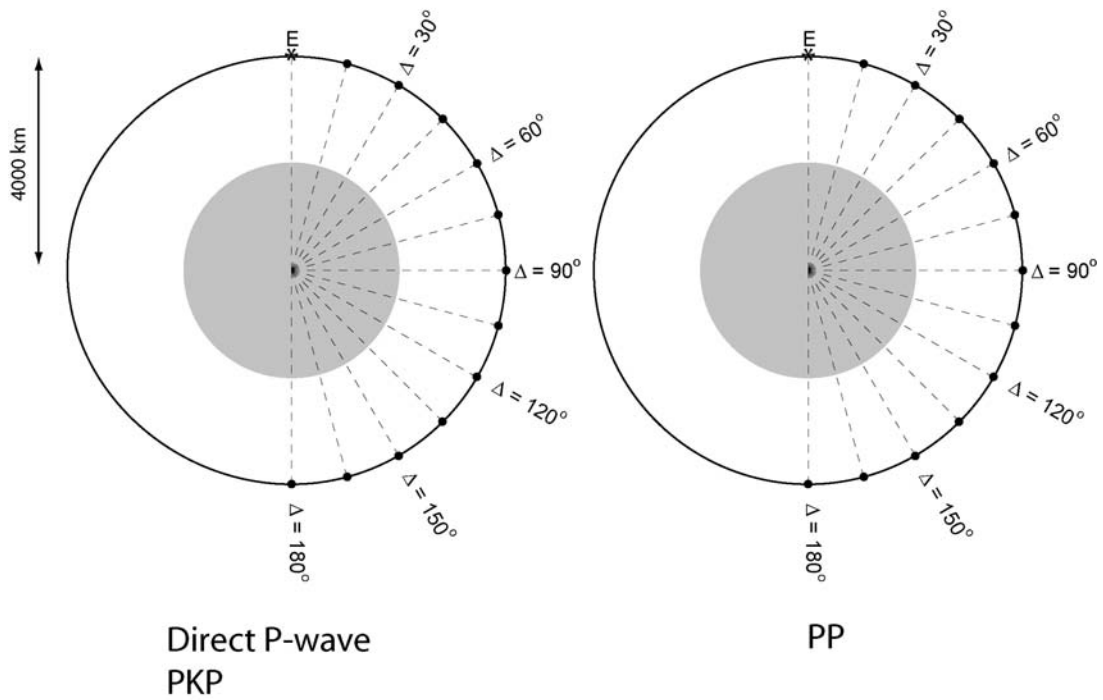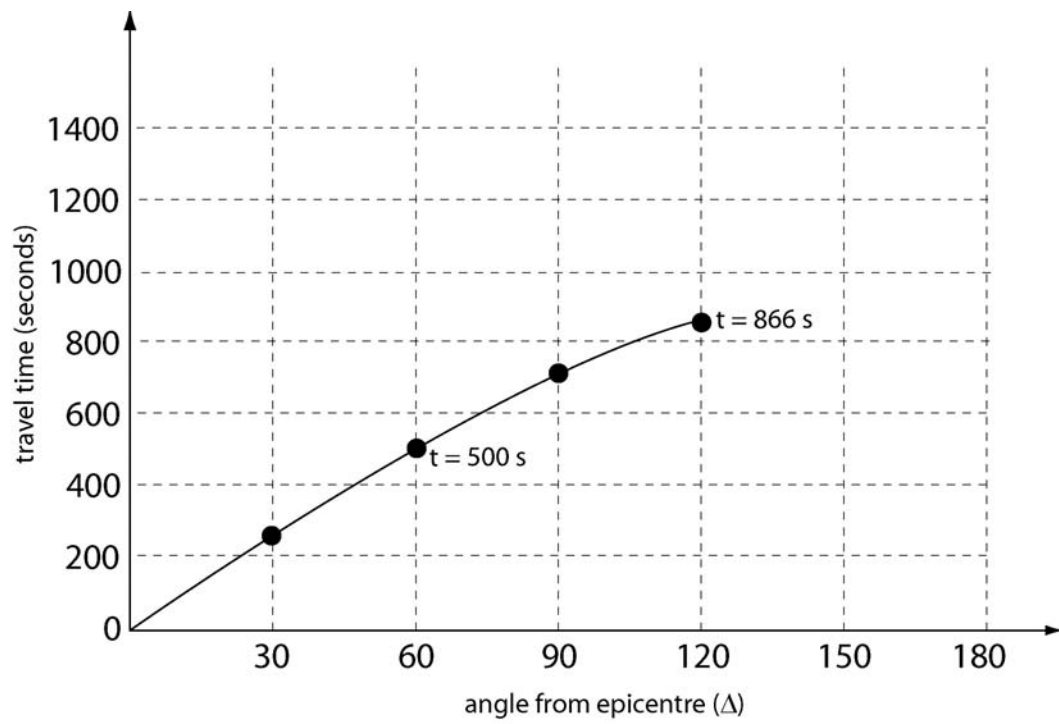(d) Direct P-waves were not observed at $\Delta > 120°$. Compute the radius of the core.　　　　　**(3 points)**

PKP (P-wave in mantle and P-wave in core)

(e) Consider the seismic waves that travel through the core and are detected at $\Delta=180°$. Sketch the **three** possible ray paths on page 5

　　　　　(5 points)

(f) One of the seismic waves in (e) wave travels directly through the centre of the Earth. This has a travel time of 1300 seconds. Compute v_c.　　**(3 points)**

PP (P-wave in mantle that bounces on surface of the planet)

(g) Sketch the raypaths for PP on page 5.　　　　　**(2 points)**

(h) What is the PP travel time when $\Delta = 180°$?　　　　　**(2 points)**

(i) Sketch the travel time curve for PP on page 5　　　　　**(2 points)**

(Q3 Total = 24 points)

travel time (seconds) vs angle from epicentre (Δ)

t = 866 s

t = 500 s

4000 km

E

$\Delta = 30°$

$\Delta = 60°$

$\Delta = 90°$

$\Delta = 120°$

$\Delta = 150°$

$\Delta = 180°$

Direct P-wave
PKP

E

$\Delta = 30°$

$\Delta = 60°$

$\Delta = 90°$

$\Delta = 120°$

$\Delta = 150°$

$\Delta = 180°$

PP

Question 4 – Geomagnetism

(a) Explain the origin of **diamagnetism** and **paramagnetism** on an atomic level.

For each indicate if the magnetic susceptibility is **positive** or **negative**.

Name a mineral that exhibits each type of behaviour.   **(10 points)**

(b) The Earth's magnetic field is generated by **three** distinct processes .

Name these **three** processes and the **percentage** of the total magnetic field
that comes from each.   **(6 points)**

(c) Describe **three** ways that a crustal rock can acquire **remnant magnetization**.

Briefly explain the origin of the magnetization in each case.   **(6 points)**

(d) Paleomagnetism is used to calculate the **paleolatitude** of a rock sample.

State 2 major assumptions that must be made about the geomagnetic field for this
approach to be valid.

                                                                     (4 points)

(e) A rock sample was found at latitude of 54°N in Manitoba.

Remnant magnetization in the sample was found to have an inclination I = 40 °
from the horizontal.

Was the rock magnetized at the location where it was sampled?   **(4 points)**

                         (Q4 Total = 30 points)