Introduction to Earthquake Seismology [GEOSC 488]
Potential Midterm Exam Questions

Fall 2003

The exam will cover Chapters 1-3 of Stein and Wysession (2003). You may need a calculator and perhaps a ruler, no other materials will be allowed. Be clear to state the meaning of all variables used in any equations.

Some of the things *you should memorize:*

- The approximate radius of the earth, inner core, and outer core.
- The relationship between ray parameter, incidence angles, and travel time curves.
- Snell's Law.
- The formulas for P and S velocity in terms of Lame's parameters.
- The gross velocity structure of Earth (*Figure 3.5.1 of Stein & Wysession*).
- The formulas that relate wavelength, frequency, velocity, and period.
- Hooke's Law for an isotropic, elastic material.

Potential Questions

1. What is an earthquake (*in a few sentences*)?
2. Where do over 90% of earthquakes occur? (*Answer: At plate boundaries*)
3. Why do we study earthquakes? What are the two major divisions in earthquake seismology research? (*Answer: The study of Earth's structure and study of earthquakes*)
4. What is the relationship between the displacement and the "potential" used in wave propagation problems?
5. Given a strain tensor, what is the associated stress tensor in an elastic material?
6. Given a stress tensor and a a fault orientation, compute the stress on the fault and resolve it into normal and shear stresses.
7. I may include a wavelength problem (identify the period, amplitude; compute wavelength from velocity and frequency; *etc*.
8. Sketch the gross P-wave velocity variations within the earth from the surface to the center. Label the approximate depth and P-velocities at the important boundaries in the earth (*see 3.5.1 of Stein & Wysession*)
9. What is a typical value of the P-velocity of the continental crust? What is a typical S-velocity of the continental crust?
10. What is Poisson's ratio? What is a typical value of Poisson's ratio for the earth's materials?
11. Given that the P-velocity of a rock is 6.8 km/s, the S-velocity is 3.82 km/s, and the density is 2.95 g/cm^3, compute λ and μ.
12. Ray theory provides an approximate solution to the equations of motion. Under what conditions is ray theory appropriate?

13. The velocity change from the base of the mantle to the outer core is negative. This change in material properties produces a "shadow zone" for P waves. What is the shadow zone physically? Over what distance range is the P-wave shadow zone known to exist? Using Snell's law, explain the existence of a shadow zone using a simple low-velocity layer sandwiched between two layers with a faster velocity.

14. Using ray diagrams, describe the following seismic phases: *P, PP, PPP, pP, sP, ScS, PS, R1, R2, sS, Pg, Pn, PmP* (*See Figures 3.2-1 and 3.5-5 and the description of crustal phases on page 122*).

15. Why do seismic waves generally curve upward in Earth's mantle?

16. In terms of seismic travel time curves, what is a triplication? What vertical velocity variation produces a triplication? (*See the discussion near page 160.*)

17. Given that the ray parameter of a P wave is 6.8 seconds per degree, and the average velocity of the shallow crust in the vicinity of a particular seismometer is 4.5 km/s, what is the angle of incidence of the P wave at the surface?

18. Consider a simple one-layer crust with a P-velocity of 6.2 km/s and 32 km thick. If the velocity of the mantle is 8.0 km/s. Sketch and label the travel times curves for the direct, reflected, and the head-wave for a surface source. Let the distance axis range from 0 to 500 km. Identify the crossover distance. Assume a Poisson's ratio = 0.25 and construct a formula to estimate the distance to an earthquake using the observed travel times of a P and an S wave at a single seismic station.

19. Consider a plane P-wave incident at the Earth's surface at an angle of 15°. If the velocity near the surface is 6 km/s, write an expression representing this plane wave in terms of complex exponentials, assuming that it's motion is in the $x_1 - x_3$ plane. Compute the horizontal and vertical slownesses for this wave near the receiver. If the velocity near the source of this wave is 8.5 km/s, what was the takeoff angle for this wave? Compute the horizontal and vertical slownesses near the source.

20. Write down the equations used to construct the reflection & transmission coefficients for a solid-solid and a solid-free surface boundary.

21. Given a dispersion curve, sketch the surface-wave seismogram to reflect the characteristics of the dispersion curve. Give an idea of what the arrival time would be at a specified distance.

22. Consider a velocity structure that consists of two layers resting on a half-space. Write an expression for the travel time of a head wave traveling at the top of the half-space in terms of the vertical slownesses within the layers (η_1 and η_2), the horizontal slowness, *p*, and the layer thicknesses *h1* and *h2*. What is the vertical slowness in the half-space?

23. Given a seismic record section compute the phase velocity of an identified wave and estimate its angle of incidence at Earth's surface (given a velocity at the surface).

24. Given a record section of a layer over a halfspace, identify the direct, reflected, and refracted waves. Use the observations to estimate the velocity of the layer and the half-space, and use the crossover distance to estimate the thickness of the layer (I'll give formula for crossover distance).

25. Given a two or three components of ground motion recorded at a particular seismic station, construct particle motion diagrams and estimate the possible directions that the wave may have approached the seismic station.