

Homework #1
Earth model manipulations
Due October 5, 2006

This exercise requires prem.m and iasp91.m which are available on the class web site

1. Plot V_p , V_s , and density for the entire Earth for PREM and IASP91.
 - a. At what depths are properties discontinuous for each of these models?
2. Using the PREM density structure, calculate the gravitational acceleration as a function of depth. Plot the results and comment on the obvious features illustrated by this graph.
3. Calculate the pressure profile for Earth. Plot the result and determine the values at the discontinuities noted in problem 1.
4. Determine the Bullen inhomogeneity parameter, η , and plot it as a function of depth for Earth. In which regions is η nearly equal to 1? Discuss the location and nature of deviations from 1. Does density increase more or less than predicted for self-compression? Over the transition zone, what is the difference between the actual density change and that expected for self-compression?
5. Plot the bulk modulus and density of Earth versus pressure. For regions with η nearly equal to 1, determine a modulus and density for the extrapolation to a pressure of 1 bar.
6. Assume $\gamma = 1.5$ (ρ_0/ρ) and that the temperature at 670 km is 1600°C (Poirier p.241). Use the ρ_0 's determined in question 5. Calculate temperatures as a function of depth through the lower mantle and through the outer core. What are temperatures at the core mantle boundary and inner core boundary under these assumptions? What is the temperature of the "released" lower mantle – ie the temperature at 1 bar pressure? Are these likely to be lower or upper bounds on the actual temperatures? Give your reasons.

Note on Numerical Integration: Simpson's Rule (trapezoidal integration) is easy in MATLAB and accurate enough for this assignment. A useful MATLAB function is cumsum that returns the cumulative sum of vector elements:

$$\text{cumsum}([1 \ 1 \ 1]) = [1 \ 2 \ 3 \ 4];$$

Given $y=f(x)$, and using an increment Δx for the integration,

1. Calculate $[y_1 \ y_2 \ y_3 \ \dots \ y_n] = [f(x_0) \ f(x_0+\Delta x) \ f(x_0+2*\Delta x) \ \dots \ f(x_0+(n-1)\Delta x)]$. This gives you a vector of length n.

2. The area under the curve at each point starting at x_0 can be approximated by trapezoidal area elements (using the average height for y between x and $x+\Delta x$):

$$\text{Area}(x) = [0 \ \Delta x/2 * (\text{cumsum}(y(1:\text{end}-1)) + \text{cumsum}(y(2:\text{end})))];$$