

Example ESE 13 Lab report:

A Sample Lab Report

NAME
ESE 13, DATE

For Dr. Sheldon Skaggs

This was written to demonstrate some of the aspects of a good lab write-up. Read it critically and try to extract ideas about organization, tone, etc. Also note the way that assumptions, error sources and conclusions are explicitly stated and related. Comments in red apply to this very first lab. After that black writing will be example to follow for each lab.

1. Introduction

In this study, a five layer velocity structure of the earth is used to compute travel times for a family of monotonically steepening p-wave rays leaving an arbitrary earthquake source. The calculated values are graphically compared with values observed by seismic stations for an actual earthquake. Velocity and layer radius parameters are then adjusted to achieve a 'best fit' to the observed data. The following assumptions are made: a) perfect radial symmetry and b) constant velocity within layers.

For the first lab, explain why Dr. Skaggs is making you access the websites and look up the people he did. What do you think he wants you to learn.

2. Procedure

The family of test rays used in this simulation was parameterized according to their take off angle using the ray parameter, P . Applying the assumption of constant velocity within each layer (straight ray paths), an angle of incidence was computed each time the ray hit a layer boundary. Depending on the velocity structure of the boundary, a reflected ray, a refracted ray or both were generated according to the following rules:

- a. Reflection: the angle of incidence on a planar boundary is equal to the angle of reflection.
- b. Refraction: Snell's law governs the angle of refraction for rays at boundaries. It states that the ratio of the velocities of the layers $[V_i/V_r]$ is equal to the ratio of the sines of the angles of incidence and refraction $[\sin(A_i)/\sin(A_r)]$.

Path segment lengths within each layer were then calculated. Using the simple relation between velocity, distance and time, travel times for each ray were calculated and plotted against delta. Delta is the angular distance between the ray source and the point where the ray reached the surface of the solid earth. This format is identical to normal travel time tables such as the J-B table.

Reflected ray paths were calculated only at boundaries where velocity increases with depth. At these boundaries, refraction occurs when the incidence angle of a ray is less than the critical angle, established by Snell's law. Rays incident on the boundary up to this critical angle are totally reflected.

These tasks were accomplished in an Excel spreadsheet. Free parameters (radius and velocity of each layer) established once, at the top of the sheet, were referred to in calculations for each hypothesized ray. The spreadsheet was divided into groups of rows, each representing a set of rays with a common path. For example, the first set represented the direct p-waves in the upper mantle. The second set represented reflected p-waves from the 650 km discontinuity. The third set represented rays that bottom out in the middle mantle layer. This pattern continued through the ray with a take-off angle of zero degrees, which propagates directly through the outer and inner cores to emerge at a delta of 180 degrees.

The travel time plot in place, free parameters were systematically varied to produce a "best fit" to the observed data, also included on the plot. Increasing the velocity of a layer generally had the effect of increasing the slope of the travel-time curve, while decreasing it had the opposite effect. Changing the depths of the boundaries affected the positions of the break points in the slope of the curve and the position of the "cusps" generated by totally reflected rays.

For the first lab, what websites and links did you visit, in what order?

3. Results

The table below indicates "best fit" values for all parameters. Note that the outer radius of the Earth and the radius of the outer core were not considered variables in this lab. Their values were fixed at accepted values published in the our text.

Layer name	Velocity, km/sec	Outer radius, km
Upper mantle	8.0	6371
Middle mantle	11.2	5840
Lower mantle	13.8	4800
Outer core	9.5	3846
Inner core	11.5	1221

For the first lab, list Person / Location / Skills in table.

4. Conclusions

Considering the gross simplification that was made in constructing this model, observed data was modeled with a good degree of accuracy. The "best fit" values of the parameters are a reasonable approximation to the accepted quantities published in FOG. This may indicate that lateral heterogeneity does not impose a effect on travel-times of earthquake rays within the resolution of the data. The small number of observed points plotted on the graph do not well constrain the calculated curve, however.

Furthermore, there is some degree of trade-off possible between parameters of the model. Small changes that worsen the fit to observations can be offset by changes to other parameters that then improve the fit. This trade-off demonstrates that the "best fit" parameters are not unique.

While this model is very simple, it demonstrates the fundamental physics of ray propagation through the Earth, as well as one of the methods whereby a radial structure of the Earth can be approximately determined using seismic observations.

For first lab, what did you learn from this lab. Would you consider a career in oceanography? Why or why not?