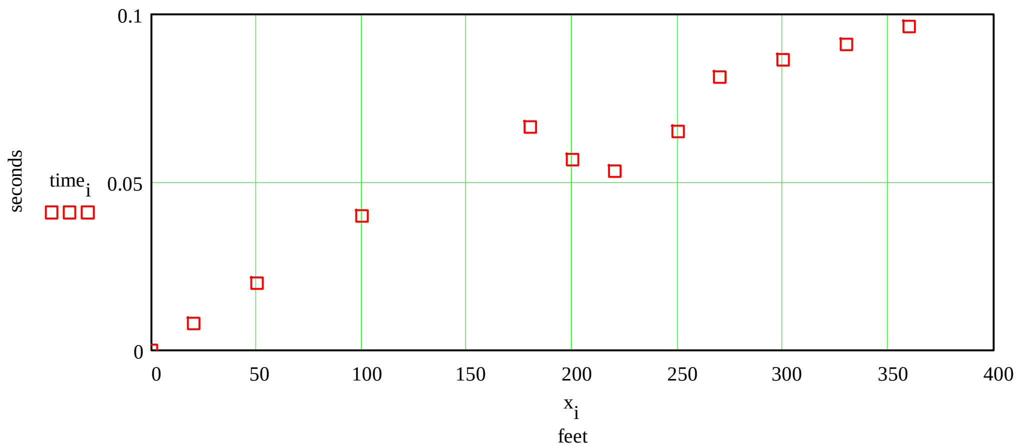
Geology 437, final exam; fall 1994.   Write your name here:

1. Here are some seismic refraction data from a one-way survey. Interpret them as best you can (e.g., velocities, rock types, structure if any, etc.), assume that a reversed line would show the same structures. Distance is in feet, time in seconds:

$x_i :=$ $time_i :=$ $i := 0 .. 11$

x_i	$time_i$
0	0
20	.008
50	.02
100	.04
180	.0664
200	.0568
220	.0533
250	.0652
270	.0814
300	.0864
330	.091
360	.0964



$$\frac{\sin(\theta_i)}{v_1} = \frac{\sin(\theta_r)}{v_2} \qquad t(d) = \frac{x}{v_1} \qquad t(r) = \frac{x}{v_2} + 2 \cdot z \cdot \frac{\sqrt{(v_2)^2 - (v_1)^2}}{v_2 \cdot v_1}$$

2.) Water does not run uphill. Yet the source of the Mississippi River is about five kilometers closer to the center of Earth than is the Mississippi delta. Explain how (and why) this can be - answer accurately, geophysically, and as if you are explaining the situation to a journalist.

3.) Two holes are constructed in a sea level plain. The first hole is bashed into the ground with a pile driver, the dirt compressed beneath. The second hole is excavated with shovels, the dirt piled next to the hole. A careful gravity survey is carried out all along the new ground surface - on the graphs provided below, accurately and carefully sketch the requested anomalies.

requested anomalies.

4.) Sketched below is some long wavelength (say 400 km) topography. In the provided space, sketch the Bouguer anomaly for the following cases:

a. elastic thickness of 6 kilometers (say 90% Airy compensation).
b. elastic thickness of 15 kilometers.
c. elastic thickness of 40 kilometers.

Explain your thinking.

5.) This is sort of like Tibet: 5 km of elevation above sea level (2670 kg/m^3), 55 km of normal crust (2670 kg/m^3), 15 km of 2819 kg/m^3 crust, and mantle (3200 kg/m^3) down to a compensation level of 100 km below sea level. Assume 100% compensation and calculate how much erosion will be needed to erode the surface to sea level.

6.) The pressure at some depth z is given by the integral below. Using the parameters from problem #5, what was the pressure at the base of the eroded section (before erosion and now exposed at the surface)? ($g = 9.8\ m/s^2$) :

$$\int_0^z p_c \cdot g\,dz$$

7.) Start with some continental crust in isostatic equilibrium. It is 35 km thick, the surface at 500 meters above sea level, 2700 kg/m^3, and floating in 3200 kg/m^3 mantle above a compensation depth of 100 km below sea level. Suppose we magically erode (or blast away) 20% of the crust. What is the new elevation (assume constant temperature, isostatic equilibrium)? Suppose 3 km of basalt (3000 kg/m^3) floods into the hole - what is the new elevation?

8.) I showed that the deflection of lithosphere due to the loading of topography is:

$$w(x) = \frac{ho}{\left[\frac{pm}{pc} - 1 + \frac{D}{pc \cdot g} \cdot \left(\frac{2 \cdot \pi}{\lambda}\right)^4\right]} \cdot \sin\left(\frac{2 \cdot \pi \cdot x}{\lambda}\right)$$

where:

$$D = \frac{E \cdot h^3}{12 \cdot \left(1 - v^2\right)}$$

a. Explain (define) the variables and constants: ho, pm, pc, D, g, E, h, v, and λ - mention their geophysical context.

b. Assume a thrust sheet impinges on the crust in two steps. After the first movement of the thrust system the rocks rest for a while and then another thrust sheet is brought in beneath the first one, each stage contributes to the foreland basin. Think about the equation (or a similar one of your choosing) carefully explain what you could learn after measuring the angle of the resulting angular unconformity. How do you expect the angular unconformity to change with distance from the load?

9.) Consider the equations:

$$T(z) = \frac{A}{k}\cdot\left(H\cdot z - \frac{z^2}{2}\right) + \frac{qb}{k}\cdot z + T(0)$$

$$\frac{dT}{dz} = \frac{A(H - z)}{k} + \frac{qb}{k}$$

$$T(z) = T(0) + \frac{Ao\cdot D}{k}\cdot\left(D - D\cdot e^{-\frac{z}{D}} - z\cdot e^{-\frac{H}{D}}\right) + \frac{qb}{k}\cdot z$$

$$\frac{dT}{dZ} = \frac{Ao\cdot D}{k}\cdot\left(e^{-\frac{z}{D}} - e^{-\frac{H}{D}}\right) + \frac{qb}{k}$$

a) Explain: A, Ao, H, D, qb, and k.

b) From a geological viewpoint, how are the equations different?

c) What is the linear heat-flow versus heat generation relationship and how do these equations fit into that relationship?