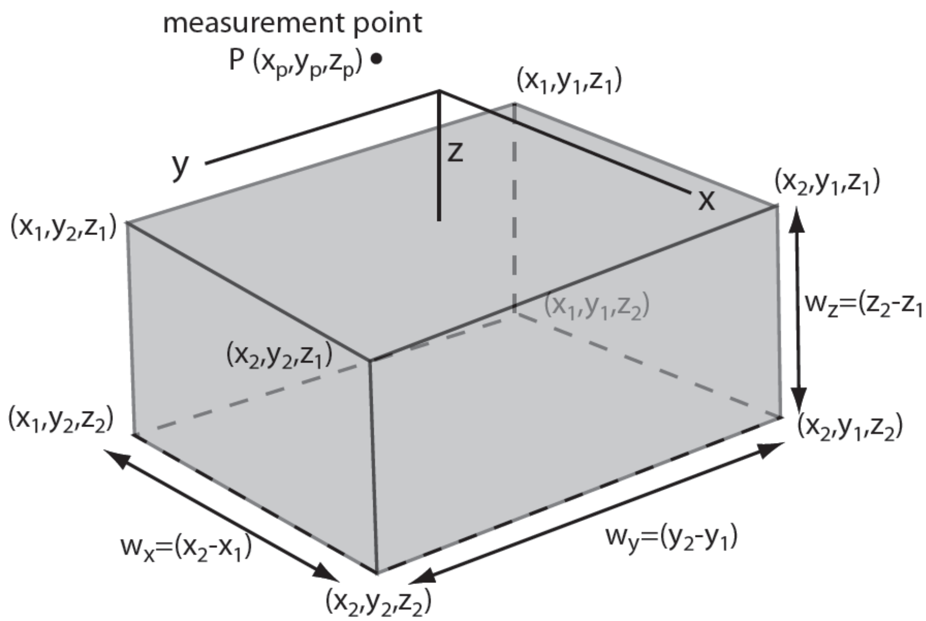
LAB 4: Gravity Anomaly from a Buried Rectangular Prism

Due 24 February

In this lab you will write, verify, and experiment with a Matlab program to calculate the gravity anomaly over a rectangular prism. The prism has a density contrast of $\Delta\rho$ from the material surrounding it, its corners are located at x_i, y_j, and z_k (i,j,k = 1 or 2) and its dimensions are w_x, w_y, and w_z and shown below.



The following equation describes the downward pull of gravity at measurement point P.

$$\Delta g = G\Delta\rho \sum_{i=1}^{2}\sum_{j=1}^{2}\sum_{k=1}^{2}\mu_{ijk}\left[\Delta z_k \arctan\left(\frac{\Delta x_i \Delta y_j}{\Delta z_k R_{ijk}}\right) - \Delta x_i \log(R_{ijk} + \Delta y_j) - \Delta y_j \log(R_{ijk} + \Delta x_i)\right]$$

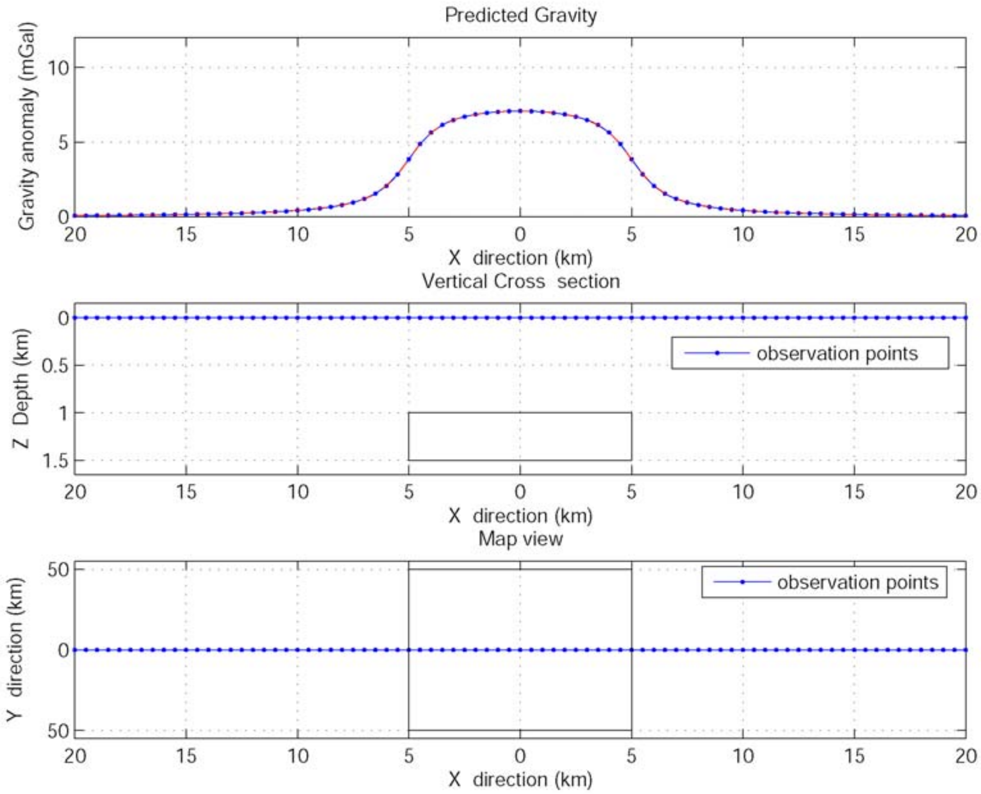
where $\Delta x_i=(x_i - x_p)$, $\Delta y_j=(y_j - y_p)$, and $\Delta z_k=(z_k - z_p)$ is the distance each corner is from point P,

$$R_{ijk} = \sqrt{\Delta x_i^2 + \Delta y_j^2 + \Delta z_k^2}\text{, and } \mu_{ijk} = (-1)^i(-1)^j(-1)^k.$$

The Matlab script “gravprism.m” is a Matlab “function” that performs the above calculation when a main program provides it with values of the above variables. The Matlab script “lab4_example.m” demonstrates how to use a Matlab “function” and a couple other commands that will be useful for this lab. Please review both Matlab scripts to makes sure you know what they are doing.

(1) First, write a Matlab script to compute the gravity anomaly Δg (with units of mGal) as a function of distance over a rectangle with an excess density of $\Delta\rho$= 400 kg/m^3, a width w_x = 10 km, a length w_y, = 100 km, and a thickness w_z = 0.5 km. Put the origin on the ground, over the center of the prism, and put the top of the prism at a depth of $z = z_1$ = 1 km. Have your profile extend along the x-axis from x = -20 km to +20 km, with measurement points every 0.5 km; therefore $y_p = z_p = 0$. (hint $x_1= -w_x/2$ and $x_2 = x_1+ w_x$, etc.).

Use “subplot(311)” to plot Δg versus x_p. Set the vertical axis to range between 0 and 12 mGal. Below this, show a vertical cross section along the plane of y = 0 showing the x, z locations of the data points along with a cross-section of the prism in “subplot(312)”. Last, show map view of the x, y locations of the data points and an outline of the top of prism in “subplot(313)”. Your plot should match that shown below. The file “gravprism_solution.txt” contains my solutions for Δg, which you can directly compare with yours.



(2) Nice job! Now you can begin to experiment with your program to get a feel for how the gravitational field varies over the body. First, generate plots with $\Delta\rho$= 200, 400, and 600 kg/m^3 keeping the other parameters unchanged. The three curves should be superimposed on the same plot, keeping the vertical axis spanning 0-12 mGal so the curves can be easily compared to eachother. Briefly, describe the similarities and differences among the three curves, concluding with a statement about how $\Delta\rho$ affects Δg. Pay attention to the total amplitude of Δg, the sharpness of the bends over the corners of the prism, as well as the overall width of the anomaly.

(3) Now lets see how Δg depends on z_1. Plot solutions for $\Delta\rho$= 400 kg/m^3, z_1 = 0.01km, 1 km, and 10km. Briefly, describe the similarities and differences among the curves, concluding with the statement about how z_1 affects Δg. Do your results make sense given to what you know about the decay of gravity as a function of distance from the source?

(4) How does the shape and amplitude of Δg depend on the width w_x and thickness w_z of the prism (keeping all other variables constant)? Please show plots to support your conclusions.

(5) Now see if you can generate two gravity anomalies with roughly the same shape and amplitude but due to two different prisms, with different values of $\Delta\rho$, w_x, w_z and/or z_1. This question will allow you to explore the ambiguity inherent to gravity anomalies: the same (or similar) gravity anomaly can come from sources of different density contrasts, shapes, as well as depths. This is a major weakness in the use of gravity anomalies, which usually necessitates independent knowledge about the local geologic structure.