LABORATORY 8 -
MEASUREMENT AND INTERPRETATION OF GRAVITY DATA

OBJECTIVES:

1. *Investigate the gradient of gravity in the ATG building*
2. *Examine how field observations of Earth's gravity field are processed to give gravity anomalies.*

BACKGROUND: Earth's gravity field can be determined from point measurements at the surface. From such data, lateral changes in the distribution of mass can be quantified and interpreted in terms of subsurface structure. A standard field instrument, the LaCoste and Romberg gravimeter, can measure changes in gravity as small as 0.1 gu (0.01 mgal) which is one part in 10^8. The measurement is not "absolute" – one compares gravity at a location with a known "absolute" value to a location where one wants to know the value. Gravimeters are delicate and expensive (the replacement cost for the one you are using is >$40K). The first thing to remember is that **THOU SHALT NOT MOVE THE GRAVIMETER WITHOUT CHECKING THAT IT IS CLAMPED.** The instrument is subject to drift problems and can measure the gravity due to tidal changes. Thus, one must move from a base station to another location and return to the base station to determine the instrumental and tidal drift. Following a "drift" correction, the absolute gravity at stations is determined by adding the gravity change to the absolute gravity at the base station.

In order to determine lateral mass variations, the effect of latitude and elevation must be subtracted from the raw gravity data.

Gravity (in gravity units) as a function of latitude is:

```
function g=grav_lat(phi)
phi=phi*pi/180;
ge=9.7803267715;
g = ge*(1 + 0.0052790414*sin(phi).^2 + 0.0000232718*sin(phi).^4 +
0.0000001262*sin(phi).^6 + 0.0000000007*sin(phi).^8) ;
```

The Free Air Gradient is:

$dg/dr = -2g/r$ g is the gravitational acceleration at the surface and r is the radius of Earth

The Bouguer Slab Correction is:

$dg/dr = 2\pi\rho G$ where ρ is density and G is the Gravitational constant (6.67×10^{-11} S.I.)
$2670\ kg/m^3$ is the standard value used for crustal studies

EXERCISE:

1. Determine how gravity changes with height by measuring gravity on all floors of the ATG building. The spacing of the floors is 13 feet except for 14 feet between floors 3 and 4. (You can assume that the height uncertainty is small and negligible).

a. Use the ground floor as your base, make measurements on higher floors and return to ground floor to check for drift.
b. You should measure gravity on each floor at least three times in order to check the precision of the measurement (when working in teams, have every member take a turn making the measurement, rotate the dial away from the best measurement each time and re-center as a new reading).
c. If you observe drift of the base station readings, you need to apply a "drift correction" to intermediate in time data.

2. Plot data with uncertainties. Determine the gravity gradient within ATG (and its uncertainty)
   a. The gradient will not agree with the Free Air value. Why? In which way does it deviate? Can you give a conceptually correct reason?
3. Model the gravity contribution of ATG as a cylinder. Determine whether the measured gradient of gravity is consistent with a plausible model for the building contribution

4. Attached are raw (field) gravity determinations along a north-south line running through Seattle.
   a. Plot station locations on a map of the area
   b. Plot gravity as a function of distance from the south end of the line (in kilometers)
   c. Remove the latitude effect and plot data as above
   d. Process data to give the Free Air Anomally and plot
   e. Process data to give the Bouguer Anomaly and plot.
5. Discuss the features observed in your plots. How does gravity vary along this profile? What is the nature of feature(s) (size, location, explanation) observed in the anomaly plots.

As always, be sure to consider and discuss the consequences of uncertainties in data.

Gravity below is acceleration minus 976000 mgal

Longitude	Latitude	Elevation(m)	Gravity (mgal)
-122.333830	47.416332	102.40	4767.80
-122.333340	47.438332	103.60	4767.80
-122.332660	47.459999	69.40	4776.71
-122.332660	47.472668	109.70	4768.54
-122.332500	47.488834	127.40	4762.91
-122.332660	47.503334	141.40	4751.21
-122.332830	47.512165	130.70	4745.30
-122.323830	47.521332	11.20	4762.80
-122.321670	47.528332	4.20	4756.60
-122.321330	47.536335	3.60	4750.10
-122.328330	47.544834	4.20	4744.40
-122.332830	47.557667	4.50	4735.60
-122.333000	47.575832	4.20	4730.85
-122.332660	47.596001	4.20	4727.96
-122.341670	47.612835	45.10	4719.30
-122.333340	47.625832	8.20	4727.80
-122.325000	47.639999	31.30	4723.85
-122.326670	47.655834	36.20	4725.56
-122.327160	47.672668	84.40	4718.75
-122.335170	47.691002	64.90	4729.24
-122.343330	47.705166	100.20	4727.32
-122.343500	47.723499	132.20	4729.16
-122.343830	47.734665	146.60	4730.46
-122.344330	47.752335	142.00	4741.21
-122.344670	47.763332	145.90	4746.90
-122.344670	47.777832	124.30	4760.00
-122.334170	47.794666	104.80	4768.71

To check your corrections, for the first observation:
-122.333830 47.416332 102.40 4767.80
the Free Air anomaly is: -381.6 gu
and the Bouguer anomaly is: -494.5 gu