AMHERST COLLEGE

Department of Geology
Geology 41: Environmental and Solid Earth Geophysics
Lab 3: The gravity field and free air correction

PART I: MEASURING GRAVITY

EQUIPMENT:
- **gravimeter**
- **tape measure**
- **thermometer**
- **spare bulb for gravimeter**
- **spare batteries for gravimeter**
- **notebook**
- **pen**

We will use a gravimeter to measure the value of gravity for a point in the earth's gravitational field, in this case, the stairway of the ESMHN Building. The gravimeter is a very sensitive instrument that precisely measures *differences* in the earth's gravitational acceleration. In order to get absolute gravity values we must use <u>our</u> meter to measure the gravity at a base station or point where the value of gravity is known. The gravity value in basement of the ESMNH Building (near main stairwell) is (980,372.14 mgal). Our gravimeter gives readings *relative* to that known value. Each team will make a series of measurements at 7 locations. One will be the "base station" in the basement, three others will be on each of the 3 floors of ESMNH and the remaining 3 will be at landings between the floors. Our gravimeter is sufficiently sensitive to register the difference in gravity due to these different elevations of the landings. In practice, the precision of the Amherst gravimeter is approximately ±0.1 mgal.

The earth's gravity field varies with time due to tidal effects (known as diurnal variations), so that you must measure the value of gravity at the same point (usually your base station) repeatedly during your gravity survey. Over relatively short periods of time (hours) the drift in the gravity field is nearly linear, so that a linear drift correction can be applied. To do the drift correction, you have to know the time that you made your measurements at your base station as well as at each of your gravity stations. Temperature affects the calibration of the gravimeter, so that the gravimeter should warm up or cool down to the ambient temperature before gravity measurements are made (keep the meter out of the sun) and the temperature must be measured at each gravity station.

OUR SURVEY WILL BE CONDUCTED IN THE FOLLOWING MANNER:
Work in small teams of four or so when using the gravimeter. While one team uses the gravimeter, the members of the other team or teams can be working on Part II of this lab.

1) Establish your base station at our point of known gravity. Record the time (and temperature) at the base station.

2) Make a gravity reading at each landing of the staircase, positioning the gravimeter as nearly as possible in sites directly above or below each other. Record the time (and temperature) at each gravimeter reading.

3) Using a tape measure, determine the vertical distance between each recording station. Elevation greatly affects the measured value of gravity, so, for our survey, the relative elevation must be determined for each gravity station with as great precision as possible ($\leq$ 0.03 m). This level of precision far exceeds the best topographic maps, so for a good gravity survey elevations must be surveyed as well (generally using GPS technology or a total station).

4) Return to the base station, rereading the gravity and recording a new time (and temperature).

5) Produce a graph of gravity (x axis) versus time (y-axis) for the base station and calculate the rate of diurnal drift over the study period, that is, determine the slope of the graph. Apply a correction factor, based on this rate of change, to each of your staircase station readings, given the time of reading for each.

ANALYSIS:

The staircase readings give you an opportunity to assess the nature of the free air correction in a gravity survey. You have been reading the value of gravity at (essentially) the same point at different distances from the earth, with (for the most part) only air between each recording station. These readings are sufficient to examine the free air correction. Plot a graph of gravity versus elevation. Does this provide a mathematical correction factor for elevation? How? What is your correction factor? Compare your result to the free air correction value given in your text (p. 171: $3.1 \times 10^{-6}\,ms^{-2}$ per m of elevation). If your value differs, why? (Note: instrument accuracy is NOT a reasonable source of differences. This instrument is capable of measuring with sufficient accuracy to properly determine the free air correction.)

USE OF THE WORDEN GRAVIMETER:

1) **LEVEL THE GRAVIMETER:** The gravimeter must be placed upon a level surface. If you use the meter on its tripod, the tripod must be leveled so that the bullseye level is centered. Place the gravity meter on the tripod or other level surface and level the longitudinal and transverse levels (#8, 9 Fig. 9) using the knobs on each of the 3 legs. Both level bubbles must be absolutely centered. The is absolutely the case for the longitudinal level (#9, Fig. 9)
2) **TURN ON THE ILLUMINATION:** Place 2 AA batteries (+ end up) in the battery case (#12, Fig. 9). Turn on the viewing light (#6, Fig 9.). The levels should become illuminated and a lighted line will appear in the eyepiece (#7, Fig. 9).
3) **NULL THE DIAL:** Adjust the small dial (#10, Fig. 9) so that the beam (illuminated line) is lined up along the center line of the eyepiece (Fig. 18). If necessary, gently tap the top plate of the gravity meter so that the beam moves from its stop.
4) **WAIT:** Wait until the meter has reached the ambient temperature (this could be a long time) and until the beam stops vibrating.
5) **READ THE SMALL DIAL:** Five significant digits can be read from the small dial. The first two (the thousands and hundreds digit) comes a window on the dial. The second two (tens and ones digit) comes from reading the top of the dial. The fifth (tenths) from using the vernier scale at the base of the dial. The number of lines from the reference line to a line matching the vertical line on the dial is the tenths.
6) **RECORD YOUR OBSERVATIONS:** Record the **time**, **temperature**, **dial reading** and **elevation** for each station.
7) **TURN DIAL READINGS INTO MGALS**
   a) Compute the relative gravity for each of your stations.

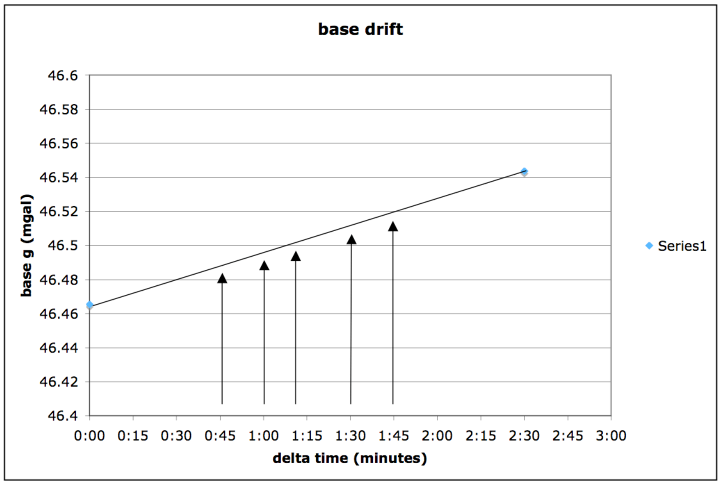
   relative g(mgals) = 0.0869 X dial reading

   b) Compute the absolute gravity for each station by applying the meter correction for the base station. Due to drift, the relative gravity at the base station will change with time.

   absolute g(mgals) = relative g (stn) + absolute g(base) - relative g (base)

EXAMPLE DATA TABLE (base station g=980372.014 mgal)

stn	*time*	*temp.*	*dial reading*
base	*10:15*	*73°*	*534.7*
1	*11:00*	*68°*	*604.2*
2	*11:15*	*66°*	*611.5*
3	*11:25*	*69°*	*665.4*
4	*11:45*	*70°*	*625.2*
5	*12:00*	*72°*	*634.1*
base	*12:45*	*75°*	*535.6*



stn		rel. g (mgal)	base g	absolute g
base		46.46543	46.465	980372.14
	1	52.50498	46.489	980378.16
	2	53.13935	46.497	980378.78
	3	57.82326	46.502	980383.46
	4	54.32988	46.512	980379.96
	5	55.10329	46.520	980380.72
base		46.54364	46.544	980372.14