GPGN 303

Lab Exercise #01: Gravimeters and Free-air Gradient

Laboratory Exercise / Handout Date: Tuesday, August 26, 2014
DUE DATE: Monday, September 1, 2014 - by 5PM to the TA!

Task:

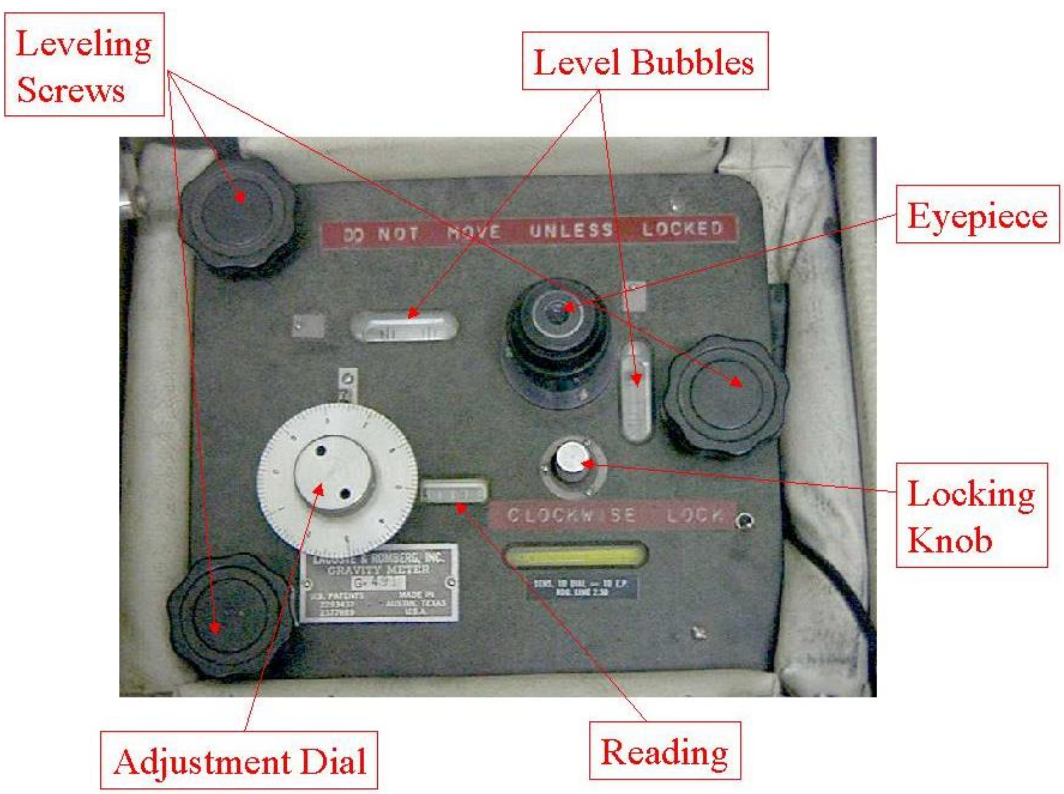
The purpose of this two-part lab exercise is to familiarize yourself with two particular land-based gravimeters and to practice the procedures for measuring the gravity field using two relative gravimeters.

Objectives:

1. Recognize the *LaCoste & Romberg Model G* and the *Scintrex CG-5* gravimeters.
2. Familiarize with the operation and storage of the gravity meters
3. Measure the free-air gradient of the earth's gravity field

Equipment:

A. LaCoste and Romberg (LNR) Model-G Geodetic Gravity Meter



Control parts:

1. Battery and battery charger
2. locking knob (clockwise to lock)
3. Leveling adjusting screws and level bubbles
4. Reading adjustment dial (decimal read-out)
5. Reading counter (integer read-out)
6. Eye piece

Storage:

1. Meter locked (to hold the spring)
2. Both meter and battery connected to charger
3. Internal lights off.

Deployment:

1. Locked,
2. The meter connected to the battery.
3. Leveled

Reading :

1. Leveled,
2. Connected to battery
3. Adjust the dial until the cross-hair at **2.4** in the eye piece
4. Always stop from the same direction consistently
5. Take reading using both the counter and dial: the first four digits on the counter gives the integer part of the reading and the dial gives two digits after the decimal point.

B. Scintrex CG-5 Autograv Gravity Meter

Control parts:

1. Battery and battery charger
2. Leveling base platform
3. Leveling adjustment screws and digital leveling display
4. Alpha – numeric key pad
5. Digital graphics display shows reading and standard deviation

Storage:

1. Gravimeter powered down
2. Meter placed back in storage case
3. Meter connected to charger which recharges batteries

Deployment:

1. Powered on
2. Base plate bubble leveled
3. Meter secured to base
4. Level using digital display

Reading :

1. Select level on menu and level using digital display
2. Navigate to start menu
3. Press record
4. Walk quickly to a comfortable spot about 3 meters away
5. Watch until the small blue light turns off
6. Return to the meter and record the relative gravity measurements (there will be 2), and the standard deviations.

Part-I (A): LaCoste and Romberg (LNR) Gravimeter Operation

1. Examine the gravity meter and become familiar with the control parts
2. List the different parts of the meter
3. Take a meter reading
   1) level the meter (works better if the long and cross directions are adjusted sequentially)
   2) unlock the meter by turning the locking knob counterclockwise all the way.
   3) turn on the light
   4) adjust the dial to position the cross hair in the eye piece at 2.4 (compensating the change in gravity). To move the crosshair towards increasing scale, turn the dial clockwise)
   5) Take the reading (integer off the counter and two decimals off the dial); denoted as **A**. record the time too.
4. Convert the reading into mGal
   1) In the supplied table (see attachment), find the nearest integer smaller than the reading from the column labeled *Counter Reading;* denoted as **B**.
   2) Find the corresponding mGal value in the column labeled as *Value in mGal;* denoted as **C**.
   3) Find the corresponding factor value in the column labeled as *Factor for Interval*; denoted as **F**.
   4) The gravity value in mGal is given by
      g=C + F*(A-B)

5. To finish the reading at a station:
   1) lock the meter by turning the locking knob clockwise all the way
   2) turn off the light
   3) secure the meter in the carrying case.

Part-I (B): CG -5 Gravimeter Operation

1. Examine the gravity meter and become familiar with the control parts
2. List the different parts of the meter
3. Take a meter reading (see attached page for additional info on setup)
4. Move to next station

Part-II: Free-air gradient

Location:

Alderson Hall, Colorado School of Mines. There are three observation locations for this lab exercise:

(S0) Absolute Gravity Station XA, steps by NE corner of Green Center; and Absolute Gravity Station DA, pad by lot at 15^{th} and Arapahoe

(S1) Main floor of Alderson Hall : near the elevator by the main entrance.

(S2) Fourth floor of Alderson Hall: near the elevator.

You are provided with the following information:

(1) The elevation difference between the two locations in Alderson: 12.34 m (34’8”).

(2) The absolute gravity values at the Gravity Stations outside the Green Center:
Station XA: 979,570.598 mGal
Station DA: 979,571.122 mGal

Procedure:

1. The measurements will be taken in the following sequence:
S0 → S1 → S2 → S1 →S0.
2. Take at least two (2) readings at each location and record the times.
3. Convert the readings to gravity values in mGal and calculate an average value for each station.
4. Calculate the average differences in gravity field between
(1) S0 and S1
(2) S1 and S2
Calculate the gravity values at S1 and S2 from the absolute gravity value at S0 and the two differences.

5. Calculate the gradient value between the two observation locations (S1 and S2):

$$\frac{\partial g}{\partial R} = \frac{\partial g}{\partial h} \approx \frac{g(h_2) - g(h_1)}{\Delta h},$$

where $g(h_1)$ and $g(h_2)$ are the gravity measurements at S1 and S2, and Δh is the elevation difference.

Compare the observed gradient value with the theoretical value of -0.3086 mGal/m. (We will discuss this in the lectures).

6. Calculate the radius of the earth using the two observed gravity values assuming that the earth is a perfect sphere and that we do not know the value of the gravitational constant or the mass of the earth.

The gravity is given by:

$$g = \gamma \frac{M}{R^2} .$$

By Taylor series expansion, we obtained the gravity difference as

$$g(h_2) - g(h_1) = -2\frac{\Delta h}{R} g(h_1) ,$$

which leads to

$$R = 2\Delta h \frac{g(h_1)}{g(h_1) - g(h_2)} .$$

Note that we need two absolute gravity values in order to use this formula.

7. Compare the calculated radius with the true value of 6,378 Km and quantify the difference.

Report:

Submit an electronic report in PDF format to your TA containing the following:

1) Your name, class, date, lab number.
2) List of the control parts of the gravimeters with brief explanations.
3) Describe the steps for taking a reading; Explain why it is important to follow the steps in the given order.
4) Record all the readings taken by the class and convert them to mGal.
5) Present the calculated value of the free air gradient, and discuss the causes of discrepancy between the observed and theoretical values.
6) Present the result of your attempt to determine the radius of the earth. Discuss the deviation from the true value. List all possible factors that contributed to the error.

<u>Attachment:</u> Conversion Table for LNR Model-G Gravimeter #G491

TABLE 1

MILLIGAL VALUES FOR LACOSTE & ROMBERG, INC. MODEL G GRAVITY METER #G- 491

COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL	COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL
000	000.00	1.02136			
100	102.14	1.02121	3600	3682.28	1.02563
200	204.26	1.02111	3700	3784.84	1.02579
300	306.37	1.02111	3800	3887.42	1.02593
400	408.48	1.02113	3900	3990.01	1.02607
500	510.59	1.02118	4000	4092.62	1.02620
600	612.71	1.02124	4100	4195.24	1.02631
700	714.83	1.02133	4200	4297.87	1.02640
800	816.97	1.02142	4300	4400.51	1.02648
900	919.11	1.02152	4400	4503.16	1.02657
1000	1021.26	1.02165	4500	4605.82	1.02665
1100	1123.43	1.02177	4600	4708.48	1.02673
1200	1225.60	1.02192	4700	4811.16	1.02680
1300	1327.80	1.02205	4800	4913.84	1.02688
1400	1430.00	1.02218	4900	5016.52	1.02696
1500	1532.22	1.02232	5000	5119.22	1.02701
1600	1634.45	1.02245	5100	5221.92	1.02706
1700	1736.70	1.02260	5200	5324.63	1.02709
1800	1838.96	1.02275	5300	5427.34	1.02712
1900	1941.23	1.02290	5400	5530.05	1.02712
2000	2043.52	1.02305	5500	5632.76	1.02712
2100	2145.83	1.02318	5600	5735.47	1.02706
2200	2248.14	1.02333	5700	5838.18	1.02698
2300	2350.48	1.02348	5800	5940.88	1.02688
2400	2452.82	1.02363	5900	6043.56	1.02676
2500	2555.19	1.02379	6000	6146.24	1.02663
2600	2657.57	1.02394	6100	6248.90	1.02649
2700	2759.96	1.02409	6200	6351.55	1.02633
2800	2862.37	1.02426	6300	6454.18	1.02616
2900	2964.80	1.02444	6400	6556.80	1.02597
3000	3067.24	1.02463	6500	6659.40	1.02576
3100	3169.70	1.02481	6600	6761.97	1.02557
3200	3272.18	1.02499	6700	6864.53	1.02537
3300	3374.68	1.02516	6800	6967.07	1.02515
3400	3477.20	1.02534	6900	7069.58	1.02495
3500	3579.73	1.02547	7000	7172.08	

* Note: Right-hand wheel on counter indicates approximately 0.1 milligal.

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