Geodesy

Natural Resources Management and Engineering 4545, Fall 2008

Thomas H. Meyer WB Young 308 860/486-2840
thomas.meyer@uconn.edu

Course Overview

Students are required to learn to set up and operate spirit levels and total stations for fieldwork exercises. Students will perform a vertical and horizontal control survey around a course of existing monuments with the purpose of computing the NAVD 88 elevations and NAD83 SPCS planimetric coordinates of the markers. Fieldwork procedures will be covered during laboratory but students should expect to perform much of the fieldwork on their own time. Students will use their knowledge of geodesy to reduce their measurements onto the GRS 80 reference ellipsoid in the NAD83 reference frame and compute geodetic coordinates of the stations. They will mathematically project the geodetic coordinates onto the mapping plane (SPCS83, CT0600) and compare distances and angles in all the coordinate systems presented in class.

Each student will perform all tasks of both surveys, meaning taking measurements, setting up reflectors and holding the stadia rods. Students will perform simple adjustments to improve their measurements and recompute closures for comparison with non-adjusted results.

Instructional Objectives

The pragmatic objective of this course is to provide the student with the scientific knowledge and technical skills to correctly produce planimetric grid coordinates (e.g., State Plane Coordinate System) using opto-mechanical instruments, like total stations. The conceptual objective of this course is for the student to acquire both an overview and specific understanding of geometrical geodesy, physical geodesy and analytical cartography such is necessary to rigorously achieve the pragmatic objective.

Over the course of the semester the student will gain an understanding of

- differential leveling and traversing with a total station,
- observation reductions,
- horizontal geodetic datums,
- geometrical geodesy,
- physical geodesy,
- analytical cartography, especially conformal projections, as applied to formal mapping systems.

The topics to be covered in the lecture include

- Horizontal Geodetic Datums
  - What are horizontal geodetic datums? Why is there more than one of them? Which ones are in use?
- Geometrical Geodesy
  - Reference ellipsoids
    - Geopotential vs. geometric
    - The relationship between reference ellipsoids and datums
    - Flattening, eccentricity, radii of curvature
  - Coordinate Systems
    - ECEF, ENU, Geodetic, Conversions
  - Distances
    - Spatial, horizontal, ellipsoid chord, chord to normal section, geodesics
  - Angles
    - Horizontal, vertical (zenith, angle of elevation), dihedral
  - Reductions:
    - Atmospheric corrections for EDMs
    - Spatial distance to ellipsoid chord
    - Deflection of the vertical
    - Skew of the normals

    - Spherical Trigonometry
        - The Forward Problem, geodetic and ENU
        - The Inverse Problem
- Analytical Cartography
    - Projections and distortions
    - Grid coordinates
    - Planimetric distances and projection scale factor
    - Planimetric angles: grid declination and arc to chord correction
- Mapping in State Plane Coordinates
- Physical Geodesy
    - Mean Sea Level
    - Gravity
    - Orthometric heights, ellipsoid heights, geopotential numbers, dynamic heights, Helmert orthometric heights

Grading

3 midterm exams, 20% each	60%
assignments	15%
Fieldwork	15%
Final examination	10%

Fall Semester 2008

Known non-meet days:
Monday, Sept. 1: Labor Day
Thursday, Sept. 4: Fieldwork
Sun Nov. 23 – Sun Dec. 1: Thanksgiving

Tentative Exam Schedule:
Tuesday, Sept. 30
Thursday, Oct. 30
Thursday, Dec. 4

Special Considerations
Any student who requires special arrangements in order to meet course requirements should contact the instructor to make necessary accommodations. Students should present appropriate verification from the University Program for Students with Learning Disabilities.

Reading Materials
Class notes entitled, "Introduction to Geometrical and Physical Geodesy: The Foundations of Geomatics," can be obtained from the instructor in digital format (pdf).

Other relevant texts include [17], any plane surveying text, e.g., [35]. For measurement adjustments see [63]

Assorted Papers
[56][57][55][59][62][61][60][58][49][6][11][3][5][4][10][9][8][7][33][12][19][2][31][40][46][38][36][50][37][16][15][53][28][24][41][52][1][51][13][34][27][54][29][25][26][23][45][47][42][14][20][43][21][18][39][44][48][32][22][30]

Reference List

1. Bomford, Guy. Geodesy. 4th ed. Oxford, UK: Clarendon Press; 1980. 561 .

2. Borkowski, Kazimierz M. Accurate algorithms to transform geocentric to geodetic coordinates. Bulletin Geodesique. 1989; 63(1):50-56.

3. Bowring, B. R. The further extension of the Gauss inverse problem. Survey Review. 1969; XX(151):40-43.

4. ---. The normal section -- forward and inverse formulae at any distance. Survey Review. 1971; XX(161):131-135.

5. ---. Distance and the spheroid (correspondence). Survey Review. 1972; XXI(164):281-284.

6. ---. Transformation from spatial to geographical coordinates. Survey Review. 1976; XXIII(181):323-327.

7. Bowring, B. R. The direct and inverse problems for short geodesic lines on the ellipsoid. Surveying and Mapping. 1981; 41(2):135-141.

8. Bowring, B. R. The geodesic inverse problem. Bulletin Geodesique. 1983; 57(2):109-120.

9. ---. The accuracy of geodetic latitude and height equations. Survey Review. 1985; 28(218):202-206.

10. ---. Notes on the curvature in the prime vertical section. Survey Review. 1987; 29(226):195-196.

11. ---. Total Inverse Solution for the Geodesic and Great Elliptic. Survey Review. 1996; 33:261.

12. ---. The central projection of the spheroid and surface lines. Survey Review. 1997; 34(265):163-173.

13. Clarke, A. R. Geodesy. Oxford: Clarendon Press; 1880.

14. Crandall, Charles L. Text-book on Geodesy and Least Squares. 1st ed. New York: John Wiley & Sons, Inc.; 1914. 329 .

15. Danielsen, J. S. The use of Bessel-spheres for solution of problems related to geodesics on the ellipsoid. Survey Review. 1994; 32(256):445-449.

16. Day, J. W. R. A refined chord-arc method of calculating geodesics. Survey Review. 1987; 29(226):191-194.

17. Ewing, Clair E. and Mitchell, Michael M. Introduction to Geodesy. New York: American Elsevier Publishing Company, Inc.; 1970. 304 .

18. Fischer, Irene. Geodesy? What's that? Ch. 2. ACSM Bulletin. 2004; 208:43-52.

19. Fukushima, T. Fast transform from geocentric to geodetic coordinates. Journal of Geodesy. 1999; 73:603-610.

20. Gore, J. Howard. Elements of Geodesy. New York: John Wiley & Sons, Inc.; 1889. 282 .

21. Groten, Erwin. Fundamental Parameters and Current (2004) Best Estimates of the Parameters of Common Relevance to Astronomy, Geodesy, and Geodynamics. Journal of Geodesy. 2004 Apr; 77(10-11):724-797.

22. Hipkin, Roger. Ellipsoidal geoid computation. Journal of Geodesy. 2002; 78(3):167-179.

23. Hooijberg, Maarten. Practical Geodesy Using Computers. Berlin, FDR: Springeer; 1997. 308 pp.

24. Höpcke, W. On the curvature of electromagnetic waves and its effect on measurement of distance. Survey Review. 1966; 141:298-312.

25. Jank, W. and Kivioja, L. A. Solution of the direct and inverse problems on reference ellipsoids by point-bypoint integration using programmable pocket calculators. Surveying and Mapping. 1980; XL:325-337.

26. Jank, William and Kivioja, L. A. Solution of the direct and inverse problems on reference ellipsoids by point-by-point integration using programmable pocket calculators. Surveying and Mapping . 1980 Sep; XL(3):325-337.

27. Jones, G. C. New solutions for the geodetic coordinate transformation. Journal of Geodesy. 2002; 76(8):437-446.

28. Keay, John. The Great Arc: The Dramatic Tale Of How India Was Mapped And Everest Was Named. New York: HarperCollins; 2000. 182 .

29. Kivioja, L. A. Computation of geodetic direct and indirect problems by computers accumulating increments from geodetic line elements. Bulletin Geodesique. 1971 Mar; 99:55-63.

30. Li, Xiong and Gotze, Hans-Jurgen. Tutorial: Ellipsoid, geoid, gravity, geodesy, and geophysics. Geophysics. 2001; 66(3):1660-1668.

31. Lin, K. C. and Wang, J. Transformation from geocentric to geodetic coordinates using Newton's iteration. Bulletin Geodesique. 1995; 69(4):300-303.

32. Malys, S. and Slater , J. Maintenance and enhancement of the World Geodetic System 1984. In. Proceedings of ION GPS-94. 7th International Technical Meeting of the Satellite Division of the Institute of Navigation; Salt Lake City, Utah. 1994: volume 1, 17-24.

33. Meade, B. K. Discussion of results obtained from the Bowring Formulae developed for solutions of the geodesic inverse and great elliptic inverse. Survey Review. 1996; XXXIII(261).

34. Meyer, Thomas H. Grid, Ground, and Globe: Distances in the GPS Era. Surveying and Land Information Science. 2002 Sep; 62(3):179-202.

35. Moffitt, Francis H. and Bossler, John D. »Surveying. 10 ed. New York: Addison-Wesley; 1998;738. ISBN: 0-6673-99752-9.

36. Moritz, H. Geodetic Reference System 1980. Journal of Geodesy. 2000; 74(1):128-162.

37. Murphy, D. W. Direct problem geodetic computation using a programmable pocket calculator. Survey Review. 1981; 26(199):11-16.

38. Pollard, J. Iterative vector methods for computing geodetic latitude and height from rectangular coordinates. Journal of Geodesy. 2002; 76(1):36-40.

39. Price, E. J. Back to basics (7) Change of geodetic datum. Survey Review. 1997; 34(265):191-203.

40. Rainsford, H. F. Long geodesics on the ellipsoid. Bulletin Geodesique. 1955; 37.

41. Robbins, A. R. Long Lines on the Spheroid. Survey Review. 1962; XVI(125):301-309.

42. Smith, D. A. and Milbert, D. G. The GEOID96 high-resolution geoid height model for the United States . Journal of Geodesy. 1999 Jun 22; 73(5):219-236.

43. Smith, James R. Introduction to Geodesy: The History and Concepts of Modern Geodesy. New York: John Wiley & Sons, Inc.; 1997.

44. Snay, Richard A. Introducing two spatial reference frames for regions of the Pacific Ocean. Surveying and Land Information Science. 2003; 63(1):5-12.

45. Sodano, E. M. in. Geodetic distance and azimuth computations for lines over 500 miles. ACIC Technical Report; 1959; 80. 41-47.

46. ---. General non-iterative solution of the inverse and direct geodetic problems. Bulletin Geodesique. 1965; 75.

47. Soler, T. Marshall J. A note on frame transformations with applications to geodetic datums. GPS Solutions. 2003; 7 (1):23-32.

48. Soler, Tomas. A compendium of transformation formulas useful in GPS work. Journal of Geodesy. 1998; 72(7-8):482-490.

49. Thomas, C. M. and Featherstone, W. E. Validation of Vincenty's Formulas for the Geodesic Using a New Fourth-Order Extension of Kivioja's Formula. Journal of Surveying Engineering. 2005; 131(1):20-26.

50. Thomson, D. B. and Vaníček P. Note on the reduction of spatial distances to a reference ellipsoid. Survey Review. 1974; XXII(173):309-312.

51. Torge, Wolfgang. Geodesy. 2nd ed. New York: Walter du Gruyter; 1997. 264 .

52. Vanicek, Petr and Krakiwsky, E. J. Geodesy: The Concepts. 2nd ed. Amsterdam : Elsevier Scientific Publishing Company; 1996. 697 .

53. Vassallo, A. and Secci, A. Unique algorithm for the calculation of geodetic distances with the solution of the first fundamental geodetic problem. Survey Review. 1995; 33(255):50-58.

54. Vermeille, H. Direct transformation from geocentric coordinates to geodetic coordinates. Journal of Geodesy. 2002; 76(8):451-454.

55. Vincenty, T. Transformation of co-ordinates between geodetic systems . Survey Review. 1965; XVIII(137):128-133.

56. ---. The meridional distance problem for desk computers. Survey Review. 1971; XX(161).

57. ---. Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations. Survey Review. 1975 Apr; XXII(176):88-93.

58. ---. Application of the chord method to solutions of geodetic lines. Surveying and Mapping. 1986; 46(4):287-292.

59. ---. Geometric Reduction of Measured Lines. Surveying and Mapping. 1986; 46(1):225-229.

60. Vincenty, T. Lambert Conformal Conic Projection: arc-to-chord correction. Surveying and Mapping. 1986; 46(2):163-167.

61. Vincenty, T. Use of polynomial coefficients in conversions of coordinates on the Lambert Conformal Conic projection. Surveying and Mapping. 1986; 46(1):15-18.

62. ---. On the Use of GPS Vectors in Densification Adjustments. Surveying and Mapping. 1987; 47(2):103-108.

63. Wolf, Paul R. and Ghilani, Charles D. Adjustment Computations: Statistics and Least Squares in Surveying and GIS. New York: John Wiley & Sons, Inc.; 1997;564.

UConn Fall Semester 2006

Monday		*Tuesday*		*Wednesday*		*Thursday*		*Friday*	
28	Classes Begin	29	Leveling	30		31	Leveling	1	
4	Labor Day	5	Total Station	6		7	Total Station	8	
11		12	Hz Datums	13		14	Hz Datums	15	
18		19	Ellipsoids	20		21	Ellipsoids	22	
25		26	Coord System	27		28	Exam 1	29	
2		3	Coord System	4		5	Distances	6	
9		10	Distances	11		12	Angles	13	
16		17	Reductions	18		19	Reductions	20	
23		24	Forward/Inverse	25		26	Projections	27	
30		31	Projections	1		2	Exam 2	3	
6		7	Scale Factor	8		9	Scale Factor	10	
13		14	Grid Angles	15		16	Grid Angles	17	
20	Thanksgiving	21	Thanksgiving	22	Thanksgiving	23	Thanksgiving	24	Thanksgiving
27		28	Vertical Datums	29		30	Vertical Datums	1	
4		5	Vertical Datums	6		7	Vertical Datums	8	Classes End
11	Finals Begin	12		13		14		15	