Syllabus, FNRM 5216: Geodesy, Coordinate, and Surveying Calculations for GIS Professionals

Credits: 1

Instructor: Paul Bolstad, Professor, FNRM, 301H Green Hall, pbolstad@umn.edu, 612-624-9711

Prerequisites: FNRM3131 or FNRM5131 or Geog3561 or Geog5561, or instructors consent

Catalog description: Where exactly are we? How do we define and refine geographic locations on a lumpy, spinning, unstable planet? On course completion students will understand concepts and practices that are at the very foundation of GIS: geodesy and geographic projections. They will have a working knowledge of geodetic datums and datum evolution, be able to make common geodetic and coordinate geometry calculations, and solve common problems that arise during datum and coordinate system conversions while engaged in the practice of GIS.

Course goals and objectives: Our primary objective is that every enrollee becomes fluent in coordinates datums, projections, and conversions. There is much confusion among GIS users about geographic and projected coordinates, the bedrock of geospatial analysis. While we often think of a static object's coordinate location as immutable, coordinates change through time due to crustal movements, improvements in our measurements, and most importantly, the conventions and methods we use to model the Earth's shape. Spatial data intended to represent the same location commonly mis-align by up to tens of meters, and vertical data are often a mess, with the same location rising or falling by up to several meters due solely to datum ambiguity. This is most often due to a poor understanding of geodesy, datums, and coordinate calculations, even among GIS professionals. Since proper metadata are often lacking, practitioners must apply forensic geodesy to properly combine spatial data. This course will provide the knowledge and tools to successfully integrate disparate spatial information. Upon course completion, the student will be able to:

- Define basic concepts in geodesy and coordinate geometry, including the geometry of spheres and ellipsoids, and perform basic location and surface distance calculations on ellipsoidal surfaces.
- Have a practical knowledge of geodetic reference systems, and be able to perform two and three-dimensional coordinate transformations among reference systems.
- Know the evolution of horizontal and vertical control datums in North America, particularly the NAD83, WGS84, ITRF systems, and NATRF2022, and be able to transform coordinates among these systems.
- Define, understand, and use different geoid estimates appropriately in vertical height measurements, particularly when integrating vertical spatial data from diverse sources, particularly LiDAR height data, alone or in combination with other data sources.
- Reduce GPS, GNSS, and coordinate surveying data to common, compatible coordinates in both three-dimensional and projected two-dimensional systems.

Required materials: Readings from the book, Geodesy for Geomatics and GIS Professionals, J.A. Elithorp, Jr., and D.D. Findorff, 2nd edition, Copely Custom Textbooks. ISBN-13: 978-1-58152-658-5, available at the campus bookstore, or at www.xanedu.com/copley, current price $70 new. Supplemental papers, provided by the instructor.

Supplementary materials:
Book, Jan Van Sickle, GPS for Land Surveyors, 4th edition, ISBN-13: 978-1466583108. Typically $40 - $90, depending on new/used, format (electronic/hardcopy), and source. Electronic access is available through the UMN Library. It is recommended students **do not** purchase this, but rather access reference copies as needed.

Book chapters, 3 and 4 of GIS Fundamentals, 5th edition, by Paul Bolstad. Supplementary materials will be on library reserve.

Course structure: We will meet once each week for one hour of lecture/discussion/case studies in a classroom or lab, and provide access to a lab equipped with computers and appropriate learning and computation software. The course schedule is attached at the end of this document. Online and hardcopy learning modules should be viewed prior to each class meeting to provide relevant preparation and background. Weekly goals will be identified, appropriate theory and practical information provided, and example problems and case-studies discussed. There will be weekly post-meeting quizzes to re-enforce key concepts, and weekly exercises/homeworks, typically due one week after assignment. Homeworks and quizzes will be entered online, with near immediate feedback, and resubmissions allowed prior to the assignment deadline. Grading will be assigned with quizzes 20%, and homeworks 80%. Grading will be on a straight scale, with an A for 90-100%, B for 80-90%, C for 70-80%, D for 60-70%, and F for <60%. There will be no exams, nor final.

Extra credit is possible, subject to discussion with the instructor, a written description of the activity, and signed approval of the activities, deliverables, schedule, and point amount and grading rubric. The intent is to allow students to expand on specific interests or opportunities for geodesy or coordinate coordinate calculation activities. Examples might include the creation of generic or flexible spreadsheets or computer code/programs for geodetic computations, an error source analysis, or a description of of best practices or methods for geomatics processing in specific conditions.

Policies: The course will be offered in accordance to Board of Regents Policies on grade definitions, student conduct, sexual harassment, equity and diversity, disability services, mental health and stress management services, and academic freedom, as described below.
http://regents.umn.edu/sites/default/files/policies/Student_Conduct_Code.pdf,
http://regents.umn.edu/sites/default/files/policies/SexHarassment.pdf,
http://regents.umn.edu/sites/default/files/policies/Equity_Diversity_EO_AA.pdf,
https://diversity.umn.edu/disability/
http://www.mentalhealth.umn.edu,
http://cei.umn.edu/support-services/tutorials/u-m-syllabus-requirements-policy-statements/academic-freedom-and,
http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html

Students are urged to contact the instructor and/or relevant University of Minnesota representative with any questions regarding any of these policies, accommodations, or expectations or actions.

Course Schedule

Week	Topics	Readings*
1	Two and Three Dimensional Trigonometry	EF: Chapter 1
2	Spherical Geometry	EF: Chapter 2, 3
3	Ellipsoid Geometry	EF: Chapter 5, 7 thu 104
4	2D and 3D Coordinate Transformation	EF: Chapter 7 remaining
5	Earth's Gravity Field and the Geoid, Part 1	Five Snay papers provided on course site
6	Earth's Gravity Field and Geoid, Part 2	EF: Chapter 8 & 9; Meyers papers provided on website
7	Realized Datums, Datum Transformations	EF: Chapter 12
8	General Map Projections	PB: Chapter 3
9	Geographic to Cartesian: the UTM System	Snyder UTM handout on course website
10	State Plane and County Coordinate Systems	Snyder State Plane handout on course website
11	Projection Application	Projections course handout
12	Image Coordinates, Matching, Transformations	PB: Chapter 4 excerpt
13	Common Tools, Best Practices, Pitfalls,	ESRI & Trimble Technical Documents
14	Case Examples	Examples course handout

*EF = "Geodesy and Geomatics for GIS Professionals,2nd Ed" by J.A. Elithorp Jr., and D. D. Findorff, ISBN: 978-1-58152-658-5; PB = "GIS Fundamentals, 5th Ed" by P. Bolstad, ISBN: 978-1-50669-587-7