KTH Geodesy and Satellite Positioning 2023-09-04
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AG1817/2926 Map projections and reference systems

1. Content description

Coordinates of ground points are the most fundamental component in geospatial databases. Coordinates should be well defined **mathematically** and **physically**. Knowledge on coordinates and their reference systems is important not only for understanding the processes of surveying and mapping but also for properly using geospatial databases.

The first part of this course concerns mathematical definitions of coordinates with respect to a reference ellipsoid and the related computations. This topics is traditionally called *ellipsoidal geodesy* or *mathematical geodesy*.

The second part of the course concerns mathematical transformation of points, lines and areas from the surface of a reference ellipsoid (or a sphere) to the map projection plane. This process is called *map projections*. The subject of map projections is also called *mathematical cartography*.

The third part of the course concerns geodetic reference systems to which coordinates are physically defined and maintained on the surface of the earth. We will discuss traditional 2D horizontal coordinate systems based on astrogeodetic triangulation and 1D vertical reference systems based on precise levelling. More importantly, modern 3D reference systems will be introduced, including astro-geodynamic phenomena which influence the definition and maintenance of modern GRS. To understand both traditional and modern GRS, astronomical concepts are essential. The course also introduces existing reference systems used in Sweden and internationally (ITRF, WGS 84, EUREF 89, SWEREF 99), as well as transformations between different types of coordinates and between different reference systems.

The courses consist of 14 lectures (**L**) and 8 computational exercises (**E**). To complete the course, one should complete all computational exercises and pass a written exam. For course participants in AG2926, a project work is also required.

2. Course literature

The following materials will be used as course literature and distributed to students at the first lesson :

H Fan (2023). *Theoretical Geodesy*. (Selected pages)
H Fan (2023). *Exercise problems on map projections and reference systems*.

3. Assessment and grading

To pass course AG1817, one should complete all exercises (LAB1, 3c) and pass the written exam (TEN1; 3c). Final grade is based on exam results and exercise performance. For the course AG2926, students need to complete a project work (PRO1, 1.5c) and deliver a project report, in addition to LAB1 and TEN1.

Conceptual criteria for final grading are given below.

Grade	*Criteria* (progressive)
E	have basic knowledge and understanding of the subjects and be able to use it in practical computations
D	have good understanding on various map projections, how different types of geodetic reference systems are built, and relationships between them
C	have good theoretical basis and be able to perform relevant numerical computations of map projection coordinates and coordinate transformations
B	have skills to analyze maps/coordinates and related problems, choose proper methods and find solutions
A	have deep insight on the subject field, be aware of existing problems, be able to identify areas for further studies.

4. Time schedule with list of lectures and exercises

L = Lecture, **E** = Exercise, **TEN** = written examination. **BB** = Seminarierum *Bora Bora* på Teknikringen 10B, bottenvåning.

Date	Day	Time	Classroom	Lecture	Exercise	Topics
2023-10-31	Tuesday	10-12	Sahara	*L1*		Introduction.
2023-11-01	Wednesday	15-17	Sahara	*L2*		Earth sphere and reference ellipsoids.
2023-11-02	Thursday	13-17	Sahara		*E1*	Spherical trigonometry and reference ellipsoids
2023-11-07	Tuesday	10-12	Sahara	*L3*		Geodetic coordinates
		13-17	Bora Bora		*E2*	Computation of geodetic coordinates
2023-11-09	Friday	10-12	Bora Bora	*L4*		Geodetic lines and basic geodetic problems
		13-17	Bora Bora		*E3*	Computation of geodetic lines
2023-11-14	Tuesday	13-15	Bora Bora	*L5*		General theory of map projections
2023-11-16	Thursday	13-15	Bora Bora	*L6*		Azimuthal and conical projections
2023-11-17	Friday	09-12	Sahara		*E4*	Projection scales. Azimuthal and conical projections
2023-11-21	Tuesday	10-12	Bora Bora	*L7*		Cylindrical map projections. UTM.
		13-17	Bora Bora		*E5*	Cylindrical map projections. UTM.
2023-11-23	Thursday	10-12	Sahara	*L8*		Spherical astronomy.
		14-16	Sahara	*L9*		Concepts of time. Astronomical positioning
2023-11-28	Tuesday	13-15	Bora Bora	*L10*		Earth rotation
2023-11-30	Thursday	10-12	Sahara	*L11*		Geodynamics. Celestial vs terrestrial reference systems
		14-18	Sahara		*E6*	Geodetic astronomy
2023-12-05	Tuesday	10-12	V12	*L12*		Astro-geodetic triangulation
		14-16	Bora Bora	*L13*		Gravity, geoid and height systems
2023-12-08	Friday	13-17	Bora Bora		*E7*	Geodetic datum and height systems
2023-12-12	Tuesday	10-12	Sahara	*L14*		3D coordinate transformation. Summary of the course.
		13-17	Sahara		*E8*	Estimation of 3D transformation parameters
2024-01-09	Tuesday	08-12	M23, M24	**TEN1**		Written examination