

APPROVED
by the academic staff meeting of
Department of Land Management and Geodesy
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GEODETIC NETWORK

Jelgava

P r o g r a m m e

Code of the study course at LLU IS Register: **BūvZ2051**

3.0 CP (48 h): lectures 1.5 KP (24 h), laboratory works 1.5 KP (24 h).

Type of assessment: Examination

The author: Armands Celms, associated professor of Department of Land Management and Geodesy.

Compulsory course of the professional Bachelor's degree level study programme "Land Management and Surveying", 2nd year 4th semester in full-time and part-time studies.

Abstract:

Students acquire the theory of geodetic measurement error and equalization, the practical use of it in geodetic network equalization, get acquainted with the display of plane cartographic projections of the Earth's ellipsoid surface, geodetic networks and their development techniques, learn to perform and analyse precise geodetic measurements as required for geodetic network installation.

The aim of the study course:

The aim of the study course is to train experts in land management and land surveying so that they can install various types of geodetic networks necessary for topographic and cadastral surveying as well as for engineering geodesy.

Learning outcomes (knowledge, skills and competence):

After completing the course students will have:

- **knowledge** of geodetic network types and their development methods, depending on the network task, accuracy and nature of the area.
- **skills** to independently perform measurements of precise angles, distances and elevations, mathematical processing of measurement results and to assess their accuracy.
- **Competence** to organize the formation of the necessary precision geodetic network by selecting the most appropriate methods and tools depending on the network task.

Relation of the study course with other subjects:

Students should have the prior knowledge in the study course "Geodesy".

Requirements for individual work: home assignments:

1. Solving problems of error theory.
2. Development of geodetic network projects for the given territories.
3. Individual studies of the theoretical.

Assessment of knowledge:

1. Two tests based on the main topics of the study course: equalization of geodetic measurements, geodetic networks and their formation methods, precision measurements in geodetic networks, design principles of geodetic networks.
2. Admission requirements to the examination: in order to be admitted to the examination, students should have:
 - 1) Completed and passed all the planned laboratory works.
 - 2) Completed and passed presentation on designing geodetic networks.
 - 3) Written and passed two tests with the grade not less than 4 points.

Procedure and requirements for settling missed lectures:

The missed laboratory works with geodetic instruments should be settled during the consultations. There is only one opportunity to rewrite failed tests (i.e., tests having the grade under 4 points). If the second try is failed, the material should be answered during the examination.

Extended content of the programme

Measurement errors and precision measurements

Types of measurement errors. The key features of accidental errors. Standard deviation, a maximum and relative error. Standard deviation of the function measured values. Error accumulation law. Measurement weight. Correlation between weight and standard deviation. Standard deviation of unit weight. Function weight of measured amounts. Weight accumulation law.

Double measurements. Double measurements of equal accuracy, their difference and standard deviation of one measurement. Double measurements of various precision. Standard deviation of unit weight.

Equalization of geodetic measurements. Types of measurement - direct, indirect, and rule measurements. The method of the least squares in equalization of measurements.

Equalization of direct measurements of the same precision. Arithmetic mean, its weight. Weight unit and standard deviation of arithmetic mean calculated by adjustment corrections.

Equalization of direct measurement of various precision. General arithmetic mean. Standard deviation of weight unit. General weighted arithmetic mean and standard deviation.

Equalization or adjustment of indirect measurements by parametric method. Parametric equations, their transformation in a linear way. Parametric equations for corrections. Normal equations, their solutions.

Adjustment of *rule's measurement* using the correlation method. Equations of rules, their transformation in a linear way. Correctional equations. Correlation normal equations, their solutions. Correction formulas.

Adjustment of the levelling network with one node. Adjustment of the levelling network using a parametric method. Node method with gradual approximations. Equivalent substitution method. Adjustment of the levelling network by a correlation method. The Popov polygon method for adjustment of levelling networks.

Projection of surface ellipsoid in a plane using ArcGIS software. The concept of cartographic projections. Zoldner's projection. Gauss projection. Transition from Gauss to Zoldner's projection. Distortion of distances and areas in Gauss projection. Universal Transverse Mercator projection UTM. Latvian coordinate system "LKS" - 92 TM. A correct choice of different projections and an understanding of how to design a project in ArcGIS environment.

Geodetic networks. The concept of geodetic networks, the principles of their formation. Geodetic network formation methods: triangulation, trilateration, polygonometry, global positioning and levelling. National geodetic networks, their division. Local and geodetic surveying nets. Geodetic network design and project quality assessment in the ArcGIS environment.

Angle measurement in geodetic networks. Angular measuring instruments: optical and digital theodolites. Measurement reading devices of an optical theodolite: a microscope with the scale, a micrometer microscope and an optical double-micrometer microscope for reading two diametrically opposite points of the arc. The principle of reading the arc of digital theodolite. Angle measurement by using an approach method.

The notion of direction. Measuring directions by closing the horizon method (Struve method). Adjustment of directions in the position point. Standard deviation of unit weight and average direction. Angle measurement in all combinations. Centring and reduction elements, their determination. Calculation of alignments and reductions. Projection of measured angles in the MicroStation and ArcGIS environment.

Measurement of distances in geodetic networks. Measurement of distances with invar tapes. Corrections of measured distances. Measurement of distances by using electro-optical (light) distance measurements. Correction of measured distances.

Triangulation. Formation of triangulation network. Measurements in the triangulation network. Equalization of triangulation networks according to the correlation method. *Rules' equation* in the triangulation networks - equations of shapes, stations, poles, bases, directional angles and coordinates. Equation linearization of the pole. Simplified adjustment of geodetic rectangle and central system.

Trilateration. Formation of the trilateral network. Measurement of trilateral edges. Angle calculation. Equalization of trilateration network by using the correlation method.

Polygonometry. Polygonometric lines and networking. Measurement of angles and sides by polygonometric lines. Evaluation of adjustment and accuracy of polygonometric lines and their networks.

Precise levelling. Instruments used for levelling network; levels with a cylindrical level, levels with a compensator and digital levels. Levelling rods. Levelling signs and their installation rules. Main sources of levelling errors. Levelling of Class I, Class II and Class III. Projection of levelling non-binding values and direction vectors in the ArcGIS environment.

Formation of geodetic networks with Global Positioning (GP) method. The concept of a global positioning system and its use in geodesy. Determination of point coordinates with global positioning. Basic methods of global positioning.

List of laboratory works.

1. Reading devices of optical theodolite's arc.
2. Measurements of directions.
3. Adjustment of levelling network using nodes and projection of numerals and directions in the ArcGIS software.
4. Adjustment of levelling network according to the equivalent supplement method and projection of numerals and directions in the ArcGIS programme.
5. Measurement of distances with light rangefinder.
6. Determination of the meter length of levelling rods.
7. Levelling with a precision level.
8. Measurements of zenith distances.
9. The development of geodetic network project in MicroStation and ArcGIS environment for the given territory.

Bibliography

Compulsory reading:

1. Helfriča B., Bīmane I., Kronbergs M., Zuments U. Ģeodēzija. Rīga, LĢIA, 2007. 262 lpp.
2. Маркузе Ю.И. Теория математической обработки геодезических измерений. Книга 2. Основы метода наименьших квадратов и уравнительных вычислений. Москва, МИИГАиК, 2005.
3. Bikše J. Augstākā ģeodēzija. Mācību līdzeklis, Rīga, RTU, 2007.
4. Korelatu metode ģeodēzisko tīklu izlīdzināšanai. Metodiskie norādījumi, Jelgava, LLU, 2001.
5. Parametriskā metode ģeodēzisko tīklu izlīdzināšanai. Metodiskie norādījumi, Jelgava, LLU, 2001.

Further reading:

1. Gilbert Strang, Kai Borre. Linear algebra, geodesy and GPS. Wellesley, Cambridge Press, 1997.
2. Žagars J., Zvirgzds J., Kaminskis J. Globālās navigāciju satelītu sistēmas (GNSS). Ventspils Augstskola, 2014, 231 lpp.
3. Закатов П.С. Курс высшей геодезии. Москва, «Недра», 1976.

Periodicals and sources of information:

1. www.mernieks.lv
2. www.lgia.gov.lv
3. www.vzd.gov.lv
4. www.geo-matching.com
5. www.gim-international.com

