UNIVERSITY OF APPLIED SCIENCES
FACULTY OF LANDSCAPING
DEPARTMENT OF GEODESY
STUDY PROGRAMME: REAL ESTATE MEASUREMENT ENGINEERING
653H14004

VINCAS ZAKARAUSKAS

UPDATE MATERIAL FOR THE STUDY SUBJECT *GEODESY* TO SUPPORT THE PROJECT "INTERNATIONALITY PROMOTION AND UPDATE OF ENGINEERING STUDY FIELD PROGRAMMES TO MEET COURSE DELIVERY NEEDS OF INTERNATIONAL STUDENTS AT THE FACULTY OF LANDSCAPING OF KAUNO KOLEGIJA/THE UNIVERSITY OF APPLIED SCIENCES" (VP1-2.2-ŠMM-07-K-02-045)

Mastaiciai
2012

Educational Institution: *Kauno Kolegija/University of Applied Sciences*
Study Programme: *Real Estate Measurement Engineering*

GEODESY

Study Subject Programme

The Annotation: introduction to the efficient application of geodetic methods in various fields of activity, analysis fundamental geodetic provisions, requirements and principles for selection of modern geodetic devices and software, for development of topographic plan projects, for processing and evaluation of the data obtained in a variety of ways and methods; analysis of state and special geodetic networks and their application in a variety of surveying work.

The Aim of the Programme includes the development of practical skills in ground spatial measurements using modern geodetic devices, elaboration of digital plans and schemes, checking of the general setting of points, lines and objects of the locality; development of students' geodetic thinking, creativity, initiative and ability to make decisions both individually and in team and assume the responsibility.

2. The Length in Credits and Hours

Structure / Study subject title	Length in ECTS credits	Lectures, hours	Practical works, hours	Consultations, hours	Individual work, hours	In total, hours	Assessment
Geodesy	5	17	43	8	65	133	Cumulative

3. Prerequisites: engineering graphics, basics of geodesy, topography, practical training for geodetic survey, mathematics 1, mathematics 2, physics, human safety.

4. Links between Learning Outcomes and Intended Study Subject Outcomes and Student Achievement Assessment Methods

Learning outcomes	Intended study subject outcomes	Study methods	Student achievement assessment methods
To adapt modern measurement devices, their processing software and GIS technologies organizing and performing special geographical projects in the optimal way.	1. Technical specifications for modern geodetic devices (precise levels, range finder, GPS devices and electronic tachometers) were characterised.	Provision of information (presentation in (*Power Point* application), discussions, one-minute reflection, virtual learning environment Moodle (developed in the course of the project "Development of e-learning in colleges of Lithuania" (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Frontal oral questioning, presentation of individual task in oral and written form, mid-term test.

	2. The possibilities of processing and exchange of geodetic data using geodetic data processing software *GeoMap* were defined.	Provision of information, demonstration, discussions, one-minute reflection, virtual learning environment Moodle (developed in the course of the project “Development of e-learning in colleges of Lithuania” (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Frontal oral questioning, presentation of individual task in oral and written form, mid-term test.
To create large scale data following the methods approved by the Government of Lithuania and regulatory acts applying them for public needs.	1. Geodetic surveying data of the locality was collected.	Provision of information, discussions, individual problem solving, case analysis, one-minute reflection, virtual learning environment Moodle (developed in the course of the project “Development of e-learning in colleges of Lithuania” (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Frontal oral questioning, presentation of individual task in oral and written form, exam.
To classify stable natural and anthropogenic objects of the Earth’s surface for formation of georeferenced map and cartographic case data sets and products according to specifications and methods approved by the Government authorized institution.	1. Geodetic surveying was linked to the national geodetic basis, and the accuracy of measurements was evaluated.	Provision of information, demonstration, discussions, individual and team problem solving, case analysis, one-minute reflection, virtual learning environment Moodle (developed in the course of the project “Development of e-learning in colleges of Lithuania” (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Presentation of individual and team task in oral and written form, written assessment method: written mid-term test, exam.

	2. Topographic plan of the locality is developed using innovative geodetic devices meeting GKTR requirements.	Provision of information, discussions, individual and team problem solving, case analysis, dealing with problems, one-minute reflection, project, virtual learning environment Moodle (developed in the course of the project “Development of e-learning in colleges of Lithuania” (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Presentation of a project, presentation of individual and team task in oral and written form, exam.
	3. The indexes of equal and unequal precision survey results of one dimension are computed, and the accuracy of obtained results is evaluated.	Explanation, self-study assignment, case analysis, one-minute reflection, virtual learning environment Moodle (developed in the course of the project “Development of e-learning in colleges of Lithuania” (BPD2004-ESF-2.4.0-03.05/0179) financed by the EU Structural Fund).	Presentation of individual task in oral and written form, exam.

5. Subject Study Plan:

Seq. No.	Titles of key topics	Contact hour number			Individual work hours	Total number of hours for study per topic
		Lectures	Practical works	Consultations		
1	Structure and control of precise digital levels, precision leveling	3	8	2	-	13
2	Structure and control of electronic range finders. Measurements using electronic range finders.	2	2	-	-	
3	Structure and control of electronic tachometers. Measurements using electronic tachometers.	2	8	-	-	4
4	Topographical planning in *GeoMap* software using digital data.	2	6	-	-	10
5	Global Positioning System (GPS). World Coordinate System WGS 84.	1	-	2	-	8
6	Control and structure of GPS devices. GPS use for real estate measurements.	2	8	2	-	12
7	Lithuanian state geodetic basis. Lithuanian coordinate system LKS 94. Direct and inverse angular intersections.	2	6	-	-	8

8	Basic concepts, objectives and tasks of metrology. Problems of measurement error theory. Measurement error classification.	1	-	2	-	3
9	Mathematical processing of equal precision survey results of one dimension. Mathematical processing of unequal precision survey results of one dimension.	2	5	-	-	7
10	Theoretical preparation for mid-term tests (according to the topics), completion of practical works, preparation for seminar	-	-	-	27	27
11	Individual works "Site topographic planning" (Coordinate systems: LKS 94 and *WGS 84*)	-	-	-	38	38
	Total number of hours for subject studies:	**17**	**43**	**8**	**65**	**133**

6. Practical *(and/ or laboratory)* **Work Topics:**

1. Leveling using precision digital levels.
2. Measurements using electronic range finders.
3. Measurements using electronic tachometers.
4. Mapping using *GeoMap* computer software.
5. Measurements using GPS devices.
6. Solutions on direct and inverse angular intersection.
7. Mathematical processing of equal and unequal precision survey results of one dimension.

7. Subject Study Outcome Assessment System: Individual Cumulative Index (ICI)

(Mid-term exams make up a part of exam/individual paper (project) performed)

Study outcomes are determined by the total index of assessment of student's knowledge and skills - individual cumulative index (ICI).

$$ICI = 0{,}5\ E + 0{,}15\ K + 0{,}15\ P + 0{,}2\ S,$$

here: E - examination, K – mid-term tests, P – practical works, S – individual works.

8. Learning Outcome Assessment Criteria:

Grade and brief description of knowledge and abilities	Detailed description of knowledge and understanding	Detailed description of abilities
10 (Excellent) Excellent performance, outstanding knowledge and skills	Excellent, outstanding, comprehensive knowledge and its application in solution of geodesy complex practical problems. Individual study of supplemental material. Excellent understanding and use of geodesy concepts, ability to analyze them in wider context of the subject. Original and independent thinking. Excellent analytical and assessment skills in geodesy, insight. Excellent preparation for further studies.	Excellent application of theoretical geodesy knowledge. Excellent accomplishment of complex nonstandard tasks. Perfect, outstanding quality of work. Excellent skills of expression and presentation. Good understanding of the content and aim of the undertaken work.
	All the objectives of studies are achieved	
9 (very good) Good knowledge and skills	Strong, good, comprehensive knowledge and its application in solution of complex practical problems. Individual study of supplemental geodesy material. Excellent understanding of the studied material, proper use of concepts. Original and independent thinking.	Very good application of geodesy knowledge. Easy accomplishment of complex standard tasks. Very good quality of work. Very good skills of expression

	Very good analytical, evaluation and synthesis skills. Very good preparation for further studies.	and presentation. Understanding of the content and aim of the applied methods and techniques.
	Not less than 90 percent of study objectives are achieved	
8 (Good) Above the average performance, knowledge and skills	Above the average knowledge and its application in solution of practical problems. Acquaintance with the set geodetic material. Ability to work individually with supplemental geodesy material. Understanding and proper application of concepts and principles. Good argumentation and reasoning of the arguments with facts. Good preparation for further studies.	Good application of knowledge. Correct accomplishment of medium complexity and difficult geodesy tasks. Good quality of work. Good skills of expression and presentation. Knowing of the methods and techniques to be applied.
	Not less than 80 percent of study objectives are achieved	
7 (Highly satisfactory) Average performance, knowledge and skills with unessential shortcomings	Average knowledge with unessential mistakes. Application of knowledge in solution of practical problems. Acquaintance with the main geodetic material. Understanding and application of concepts and principles. Integration of several key elements. Sufficiently good argument. Sufficient preparation for further studies.	Application of knowledge is based on given examples. Good quality of work. Correct accomplishment of medium complexity tasks. Sufficient skills of expression and presentation.
	Not less than 70 percent of study objectives are achieved	
6 (Satisfactory) Below average performance, knowledge and skills with substantial shortcomings	Below average knowledge, mistakes. Application of knowledge in solution of simple practical problems. Acquaintance with the main material. Sufficient understanding of concepts, ability to describe the received information in own words. Analysis focuses on several aspects but fails to interrelate them. Satisfactory preparation for further studies.	Application of knowledge is based on given examples. Satisfactory quality of work. Ability to work by analogy. Correct accomplishment of simple tasks, failure to perceive more complex ones. Satisfactory skills of expression and presentation.
	Not less than 60 percent of study objectives are achieved	
5 (Sufficient) Knowledge and skills meet minimum criteria	Geodesy knowledge meets minimum requirements. Application of knowledge in solution of simple practical problems. Simple citation of assimilated concepts, retelling of text. The answer is focused on one aspect. Minimum preparation for further studies.	Minimum satisfactory abilities to solve problems in accordance with examples. Ability to work by analogy. Satisfactory skills of expression and presentation.
	Not less than half of study objectives are achieved	
4 **Insufficient** Knowledge and skills do not meet minimum criteria/below minimum criteria **3** **2** **1**	Geodesy knowledge does not meet minimum requirements.	Abilities do not meet minimum requirements.
	Less than half of study objectives are achieved	

9. Attendance.
Attendance of practical work sessions is compulsory.

10. Facilities and Learning Resources Required and Their Brief Description:
Lecture halls are equipped for geodesy teaching. Technical means: training polygon. Presentation equipment, Internet, electronic range finders „*Spectra Precizion HD* – 50“, „*Disto* A3“ and „*Disto* A5“. Electronic

tachometers: „*GPT* 3005 N“, „*Nikon NPL* - 632“, „*Trimble S 6 DR* 300+“ and „*Leica TCR* 1205 R 100“.Electronic digital levels: „*Leica DNA* 03“, „*Leica Sprinter* 200 M“, and „*Topcon DL* – 102 C“. Leveling metering-rods, leveling bases. Personal computer with special training software „*Topcon link*“, *Leica Geo Ofise*“, *Trimble Geomatics Office*, *GeoMap.*

- References and other sources of information:

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	*(a tick-mark shall mean availability of the source)*		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodesy: training aid.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	HARRY, L. *Landscape Surveying.* ISBN 9781111310608. 256 p.*	Department of Agricultural Engineering, Oklahoma State University, USA	√		√
4	2012	Charles, D., GHILANI et al. *Elementary Surveying.* ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
5	2012	E., V., ZOLOTOVA. R., N., SKOGOREVA. *Geodesy with cadastre basics.* ISBN 978-5-919840-07-7. 413 p.*	Fund “Mir” (Russian: Фонд ,,Мир“)	√		√
Additional reading						
1	1998	SKEIVALAS, Jonas. *Electronic geodetic tools* ISBN 9986-05-713-2. 193 p.	Technics	√		√
2	1995	SKEIVALAS Jonas. *Mathematical processing of the results of correlated geodetic measurements.* ISBN 9986-05-151-7 : 10.00 . 272 p.	Technics	√		√
3	1996	TAMUTIS, Zigmas. et al. *Geodesy-2* ISBN 5-420-01331-2. 384 p.	Science and Encyclopaedia Publishing Centre	√		√
4	1992	TAMUTIS, Zigmas, et al. *Geodesy-1* ISBN 5-420-01331-2. 292 p.	Science and Encyclopaedia Publishing Centre	√		√
5	2011	M. I. KISILIOV, D. S. MIHELIOV. *Geodesy.* ISBN: 978-5-7695-8390-2 (9785769583902). 384 p.*	“Akademija” (Russian: ,,Академия“)			
6	2009	I. F.,KUSHTIN, V. I. KUSHTIN *Geodesy* . ISBN: 978-5-222-15779-4. 912 p.*	“Fenix” (Russian: ,,Феникс“)			
7	2012	TORGE, WOLFGANG; MÜLLER,	University of	√		√

		JÜRGEN. *Geodesy*. ISBN 978-3-11-020718-7. 539 p.*	Hannover, Germany.			
8	2003	ERIK W. GRAFAREND, FRIEDRICH W. KRUMM, VOLKER S. SCHWARZE. *Geodesy – The Challenge of the 3rd Millennium.* ISBN-10: 3642077331. 487 p.*	Springer – Verlag Berlin Heidelberg	√		√
9	2012	Edited by G. G. POKLAD. *Geodesy practicum*: textbook for HEIs. 2nd edition. ISBN 978-5-98426-115-9. 470 p.*	"Gaudeamus"			
10	2000	Technical regulations of geodesy and cartography. *GKTR 2.08.01:2000: constructional geodetic engineering investigations*	National Service of Geodesy and Cartography	√		√
11	2000	Technical regulations of geodesy and cartography. *GKTR 2.11.02:2000: conventional signs for topographic maps of scale M 1:500, 1:1000, 1:2000 and 1:5000*	National Service of Geodesy and Cartography			
12	2013	*AutoCad (Autodesk Product Design Suite for Education 2013)**				
Periodicals						
1		*Geodesy and cartography*. ISSN 1392-1541	Technics	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilnius Gediminas Technical University, Institute of Geodesy	√		√
3		*Measurement engineering and GIS.* ISSN 2029-5790	College of Kaunas	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.gpspartneris.lt				
4		http://www.infoera.lt				
5		http://www.geoportalas.lt				
6		http://www.gps.lt				
7		http://www.glonas-center.ru				
8		http://www.unavco.org				
9		http://www.navstar.com				
10		http://www.esa.int/esaNA/galileo.html				
11		http://www.gsb.lt				

*references for international students

Subject Programme has been prepared by: assistant Vincas Zakarauskas

Teacher, coordinating the Subject: lecturer Aurelijus Živatkauskas

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VINCAS ZAKARAUSKAS

PROJECT WORK PROCEDURE FOR THE SUBJECT *GEODESY*

Mastaiciai
2012

The Aim and Objectives of the Work: to create site topographic plan, to perform geodetic surveying using GPS device.

The Main Objectives of the Project Work:

1. To define boundaries of the site.
2. To collect initial geodetic data.
3. To define geodetic network and site plan base points.
4. To select GPS device.
5. To provide detailed technical data for GPS device.
6. To carry out GPS surveying.
7. To process GPS surveying data.
8. To assess surveying precision.
9. To create a site plan.
10. To create a file.
11. To present a report.

The Length of the Project Work in Hours: 38

Expected Outcomes: To collect the data on site geodetic surveying, to link geodetic surveying to the national geodetic base and evaluate surveying precision, create a site topographic plan using innovative geodetic instruments that meet GKTR requirements.

RECOMMENDED TOPICS (TASKS)

1. Preparatory works.
2. Site examination.
3. Geodetic surveying.
4. Data processing.
5. Site topographic plan.
6. File creation.
7. Report presentation.

STRUCTURE OF THE WORK

I INTRODUCTION

Introduction must include description of work object, relevance of the analysed topic, the object, aim and objectives of the work. The style must be clear and explicit. Each statement must be justified using simple sentences. Use the following form of sentences: “Object of the work– ...”, “Aim of the work– ...”, “... is analysed in the paper” etc.. Paper structure is briefly described, and relevance is factually discussed.

It is recommended to write ***the aim of the work*** separately in bold italic.

The objectives must be numbered and arranged in separate paragraphs.

The following questions must be answered in the introduction:

What is the object of the work?

What goals must be achieved in the work?

Why to achieve them?

How will be the goals sought?

The list of basic terms and abbreviations with explanations is provided next to the introduction on a separate page (expressions (key concepts), applied terms (concepts), summaries are clearly and briefly described).

II WORK PROCEDURE

Student must analyse study and technical literature and other information sources (textbooks, monographs, scientific publications, standards and normative documents, information from web sites etc.) in detail during the preparation of the project paper.

In the work preparation procedure the student considers work specificity and envisaged outcomes.

It is required to follow the requirements of geodesy and cartography regulations of the Republic of Lithuanian during implementation of processes of the site topographic map .

Geodetic surveying is carried out using GPS device.

Site topographic map M 1 : 500 is created by *GeoMap* software.

III MATERIAL ANALYSIS

The analysis chapter must include students’ explanations on the procedure of data collection, analysis and obtained outcomes. Each visual form must explained.

More attention is paid to the description of data collection procedure and justification of the precision of obtained data.

IV CONCLUSION

The most important conclusions are formed in this chapter. The material is provided in laconic manner in the form of theses with minimum figures (do not use tables or diagrams - they must be provided in description or appendices). Conclusions need to be numbered and arranged in paragraphs. The author must sign under the conclusions.

V SOURCES OF INFORMATION

Description of used sources and literature bibliographies is provided herein. This chapter comprises description of used sources and literature compiled in accordance with the standards for document bibliography. Only directly quoted data sources or conception paraphrase (quoting) as well as the sources containing information (numbers, models, figures etc.) must be mentioned.

Preparation work, bibliographic references and their list is drawn up according to the Lithuanian standards LST ISO 690 and LST ISO 690-2. Some recommendations are provided in the methodological guidelines. References are given after conclusions in separate chapter titled SOURCES OF INFORMATION (not numbered).

Each source of information referenced in the text must be listed in the source list. You can not specify any references not mentioned in the text.

List the information sources in alphabetical order using the author's last name. Composite works without indicated authors on the title-page/cover (usually published by organisations or group of authors) are listed according to the initial letter of the heading. Several works of the same author are listed according to the publication year in chronological order starting with the earliest publication (e.g.: 1995, 1999, 2001 etc.)

Information sources in Lithuanian and other Latin alphabet based languages (English, German etc.) are listed in common alphabetic order. Slavic alphabet sources are listed separately following Latin. Foreign language sources must be written in original. All information sources must be numbered.

Description of used information sources includes: surnames and initials of author or authors, title of publication, place of publication, publishing house, publishing year. General number of pages may be indicated as an option. Note that the international standard book number (ISBN, ISSN) must be indicated at the end. This number allows to easily find publications over the Internet.

Cited book page is not indicated in the list of information source. However the cited page of article thesis work must be indicated.

Example of the list of sources is provided hereinafter.

Books: (Publication title is written in italics)

• book with one author:

ALEKNAVIČIUS, Pranas. *Žemės teisė: vadovėlis*. Kaunas: UAB „Judex“, 2007. 296 p. ISBN978-9955-448-92-1.

• book with two authors:

JANKAUSKIENĖ, Erika; ir NENORTAITĖ, Birutė Emilija. *Inžinerinė grafika: inžinerinės grafikos mokymo priemonė*. Kaunas: Kauno kolegijos leidybos centras, 2009. 138 p. ISBN 978-9955-27-155-0.

• book with three authors:

REKUS, Donatas; URBANAVIČIUS, Valdas ir PAKROSNIENĖ, Irina. *Georeferencinės duomenų bazės: mokymo(si) priemonė*. Vilnius: UAB „Vaistų žinios“ 2008. 72 p.

• book with four and more authors:

ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* Vilnius: UAB „Vaistų žinios“ 2008. 329 p.

• book with one editor:

Lietuvių kalbos žinynas. Sudarė Petras Kniūkšta. Kaunas, 2002.

• book with no author:

Respublikinė mokslinė – praktinė konferencija *„Matavimų inžinerija ir GIS“ Straipsnių rinkinys* 2010/1. Kaunas: Kauno viešoji biblioteka, 2010.

• magazines, newspapers and other continuous publications

Tarp knygų: Vilniaus Gedimino technikos universitetas, *Geodezijos instituto bibliotekos žurnalas.* 2004. Nr.1 (101). Vilnius. 2000, p. 94-106.

Articles:

• article with one author from a book or multi-volume publications:

SIKORSKYTĖ, Aušra. *Triukšmo žemėlapio sudarymo ypatumai MapNoise programine įranga. In Respublikinė mokslinė – praktinė konferencija „Matavimų inžinerija ir GIS“ Straipsnių rinkinys 2010/1*. Mastaičiai: Kauno kolegijos leidybos centras, 2010, p.14-18. ISSN 2029-5790

• article with two authors from a book or multi-volume publications:

MOZGERIS, Gintautas; ir MASAITIS Gediminas. *Lietuvos miškų aerofotografavimas: iššūkiai bei perspektyvos. In Respublikinė mokslinė – praktinė konferencija „Matavimų inžinerija ir GIS“ Straipsnių rinkinys 2010/1.* Mastaičiai: Kauno kolegijos leidybos centras, 2010, p.14-18. ISSN 2029-5790

• article from magazines, newspapers and other continuous pablications:

BAGDONAS, Algis; ir SURVILA, Romualdas. *Kuriama darni žemėtvarkos sistema. Žemėtvarka ir hidrotechnika* [magazine]. Vilnius: AB „Spauda“ 2010, p.13-19. ISSN 1648-3014.

WRIGLEY, E.A. Parish registers and the historian. In STEEL, D.J. *National index of parish registers*. London, 1968, vol. 1, p. 155-167.

• article from a book:

SKEIVALAS, Jonas. Elektromagnetinių virpesių sklidimo greitis. In *Elektroniniai geodeziniai prietaisai.* Vilnius, 2004, p. 19-20.

WRIGLEY, E.A. Parish registers and the historian. In STEEL, D.J. *National index of parish registers*. London, 1968, vol. 1, p. 155-167.

Electronic documents:

• electronic books, data bases, computer software:

URBANAVIČIUS, Valdas; GIRKUS, Romualdas; SKAČKAUSKAS, Milanas. *Kaunas topografiniuose žemėlapiuose XIXa-XXa. I p.* [CD-ROM]. Mastaičiai: Kauno kolegijos leidybos centras, 2010. ISBN 978-9955-27-189-5.

Lietuvos Respublikos Civilinio kodekso patvirtinimo, įsigaliojimo ir įgyvendinimo įstatymas
[interactive]. 2000 m. liepos 18 d. Nr. VIII-1864 ,Vilnius [visited on 16 March, 2010].
Internet access:
http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=390714&p_query=statybos&p_tr2=2

CARROL, Lewis. *Alice's Advantures in Wonderland* [interactive]. Texinfo ed. 2.1. [Dortmund, Germany]: WindSpiel, November 1994 2001 [visited on 10 February, 1995]. Internet access: <http://www.germany.eu.net/books/carrrol/alice.html>.

• articles from electronic books, databases, computer software:

Bibliografinė Europos Sąjungos oficialiųjų dokumentų bazė [interactive]. Vilnius: Lietuvos nacionalinė Martyno Mažvydo biblioteka. Informacijos centras [visited on 16 March, 2010].
Internet access: ,<http: //www.lrs.lt: 10000/esaa/plsgl/esaa web.login>.

MCCONNELL, W.H. *Constitutional History,* In The Canadian Encyclopedia [CD-ROM].
Mcintosh'o versija 1.1. Toronto: McClelland&Stewart, c. 1993. ISBN 0-7710-1932-7

• electronic serial publications (newspapers, magazines and other continuous publications): *Informacijos mokslai* [interactive]. Vilnius: Vilniaus universiteto leidykla, 1994- [visited on 9 November, 2001]. Internet access: http://www.leidykla.vu.lt/inetleid/inf-mok/infmok.html>

• articles from electronic publications (newspapers, magazines and other continuous publications): GUDONIENĖ, Vilija. *Politinė visuomenė ir informacija*. In Informacijos mokslai [interactive]. 1998, [nr.] 9 [visited on 9 November, 2001], ekr.3. Internet access: <http://www.leidykla.vu.lt/inetleid/inf-m-9/index.htmll>.

STONE, Nan. *The Globalization of Europe*. In Harward Business Rewiew [interactive]. May-June 1989 [visited on 3 September, 1990], ekr. 1-2. Access through: BRS Information Technologies, McLean (Va.).

WORK PROCEDURE:

1. Groups of 3-4 students are made.
2. Geodesy teacher specifies site borders on the locality.

Students of the group:

3. Collect initial geodetic data.
4. Examine the site.
5. Determine topographic map base points and mark them.
6. Select and check the GPS device.
7. Prepare GPS device for surveying.
8. Create locality sketch.
9. Determine site location using GPS device.
10. Transfer numerical data of measurement to computer.
11. Print GPS surveying report.
12. Evaluate surveyed data precision.
13. Process surveying data using *GeoMap* software.
14. Following Geodesy and cartography technical regulations create digital and analogical map M 1 : 500.
15. Create file.
16. Present report.

PAPER FORMATTING (FONT, FORMAT, STRUCTURE ETC.)

The text should be typed on one side of the paper 17 x 26 cm leaving margins: left – 30 mm, right – 10 mm, top – 20 mm, bottom – 20 mm, in 12 pt size *Times New Roman* font (*Normal* option) and 1,5 line spacing.

Each chapter should be started on new page. Sections may be written on the same page dividing them from the text by double line spacing according to fig. 1.

1. GEODETIC DEVICES (Level A)
1.1. Electronic devices (Level B)
1.1.1. Calibration of electronic devices (Level C)

Fig. 1. Style of headings of chapters

Center the text on full width of page. Space the paragraph from the left edge of the paper to 12-15 mm. The text is not divided into columns.

The paper must be neatly bound.

All pages (including title page, task, tables, illustrations, appendices drawn on separate pages) should be numbered. Title page is considered the first page of the paper, but the number is not inserted.

All noticed mistakes must be thoroughly corrected; white corrector may be used for the purpose. One page may contain at most five insignificant character corrections. Number the pages at right bottom of the page, 10 pt. font size. Use *Headers* and *Footers* if needed (optional) as well as *Footnotes*. Separate all of them from the document body by continuous slash with 1- 1.5 point spacing (to visually separate from the text). In addition, they must be written in 10 pt font size or otherwise highlighted. If *Headers* and *Footers* are used, their content must be meaningful.

Limit the number of various highlighted places and emphasis not to tire reader's eyes.

It is recommended to use 12 pt *Italics* for main characters of mathematical expressions and 9 pt – for indexes. Matrices should be written in square brackets, vectors - 12 pt *Bold*. Formulas should numbered by Arabic numbers in circular brackets. They must be centred, and their numbers indicated on the right side of the page.

Every new symbol of the formula has to be explained. Comma should be added after the formula, and explanation starts from the word "here" written in small letters on a new line, without indentation. Do not place a colon after the word. Each meaning of the symbol should be explained from new line (after a hyphen) in the order the formulas are provided in the text. Place a semicolon after each symbol explanation and a dot – after the last explanation. For example, average deviation is calculated according to the formula:

$$S = \frac{X_{\max} - X_{\min}}{K}, \qquad (4.1)$$

here: X_{max} – maximum value;

X_{min} – minimum value;

K **–** factor corresponding to amplitude value.

It is required to place reference to the cited literature source in the text prior to the formula.

Figures and tables should be placed next to their description in the text.

Write captions in small letters, 10 pt *Bold* font (e.g.: **fig. 2.1. Population change**). Centre the figures and their captions. Perform numbering of all figures according to chapter numbering (numbering of section is not relevant) e.g.: chapter 2 is a *theoretical part*, if it comprises figures, then the numbering is: fig. 2.1. , fig. 2.2. etc..

Large-size tables and figures should be placed in the top or bottom of the page, centred. It is recommended to check the figures printed – they must be pure and clear.

Write captions for a table above the table in small letters, font size 10 pt Bold, in the centre of the page, e.g.: **Coding of geoobjects.** Number of table should be placed one line above, font size 10 pt *Italic*, aligning along the right margin**.**

The table in the body text must occupy at most 2 pages. If the table is longer, it must be placed in appendices providing only main results of the table in the text (contracted table can be made) and reference to the appendix.

It is recommended to fill in the table using 10 pt font size and single spacing and the font different from the body text. Numbers in columns must be aligned to decimal tabs (according to the Lithuanian standard a coma **(", ")** not a dot (".")). Write "x table continuation", where x is a table number on each page occupied by the table. "End of table" instead of "continuation" must be written on the last page. Repeat table column title or at least the number of columns on each table page.

Introduction, conclusion, list of references, main concepts, list of abbreviations with explanations, list of tables, figures and appendices should not be numbered. Chapters, sections, figures, tables, formulas and appendices should be numbered: chapters with one number, sections – with two or more, others – custom. It is recommended to align along the left margin. Indentations are allowed. Headings, tables, figures and formulas should be divided from the document body by single line spacing. Headings of chapters and sections should be centred.

Figures, tables, formulas etc. must not be placed at the end of chapter or section. Chapter or section must end with summarizing sentence about the essence and main results of the chapter.

Internal appendices even though they represent equipment handouts or their copies must have a number and title. If the appendix consists of several pages, indicate its continuation or end.

When several authors, composite authors or publications must be indicated in the text, authors' surnames and titles of publications may be indicated and source sequence number in brackets, e.g.: Expansion of agriculture reorganization is envisaged in the documents [20, 21] of the Government. Realization opportunities and methods of the reorganization are analysed by J.Čaplikas [3], A.Šimėnas [4] and other authors [10,11,12].

The references provided in the text should be numbered in Arabic numbers in square brackets (source number only is specified, chapters and pages are not specified). The list of references with heading "References" (font of the chapter heading) is provided next to the conclusion (before internal appendices). The reference sources should be in original languages in accordance with the Lithuanian standards. Refer to the list of entries arranged in the order they are mentioned in the text. The sequence of references complies with their sequence in the text. The list should not contain any source which is not referenced in the text.

Topographic map is provided on A3 format pages with margins 25x5x5x5 mm.

Drawings are made using computer software. A table with main information must be placed in the right bottom corner of the drawing. Map scaling should be M 1:500.

Standard conventional symbols should be used for the map. Other symbols are allowed in case there are no appropriate symbols in the standard or decision to use them is not taken. Standard symbol are described in the geodesy and cartography technical regulation applicable in Lithuania: GKTR 2.02.02.:1999; GKTR 2.11.02.:2000. In case of non-standard symbols, provide their descriptions.

Structure of the project work:

- Title page
- Table of contents
- Introduction
- List of main terms and abbreviations with explanations
- List of tables, figures and appendices

1. Work procedure
2. Material analysis

3. Graphical part
   - Conclusion
   - Sources of information
   - Appendices

WORK ASSESSMENT:

Project Work Assessment Criteria:

Grade	Detailed description of criteria
10	All the initial geodetic data required for the project is collected, topographic map base points are envisaged and set out at the site, GPS device is selected and checked, GPS device is prepared for surveying, site location sketches are made, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is created according to the requirements of Geodesy and cartography technical regulations, a file is created in accordance with established procedure, the text in the file is readable, excellent presentation of a report.
9	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and set out at the site, GPS device is selected and checked, GPS device is prepared for surveying, site location sketches are made, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is created according to the requirements of Geodesy and cartography technical regulations, a file is created in accordance with established procedure, the text in the file is readable, very good presentation of a report.
8	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and set out at the site, GPS device is selected and checked, GPS device is prepared for surveying, site location sketches are made, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is partially created according to the requirements of Geodesy and cartography technical regulations, a file is created in accordance with established procedure, the text in the file is unreadable in some places, good presentation of a report.
7	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and only part of them is adequately set out at the site, GPS device is selected and checked, GPS device is prepared for surveying, site location sketches are made, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is partially created according to the requirements of Geodesy and cartography technical regulations, a file is created in accordance with established procedure, the text in the file is unreadable in some places, highly satisfactory presentation of a report.
6	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and only part of them is adequately set out at the site, GPS device is selected and checked, GPS device is not completely prepared for surveying, site location sketches are made, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is not printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is partially created according to the requirements of Geodesy and cartography technical regulations, a file is created in accordance with established procedure, the text in the file is unreadable in some places, satisfactory presentation of a report.

5	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and only part of them is adequately set out at the site, GPS device is selected and checked, GPS device is not completely prepared for surveying, site location sketches are made inaccurately, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is not printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 is partially created according to the requirements of Geodesy and cartography technical regulations, a file is created not following the established procedure, the text in the file is unreadable in some places, sufficient presentation of a report.
4 and lower	All the initial geodetic data required for the project are collected, topographic map base points are envisaged and only part of them is adequately set out at the site, GPS device is selected and checked, GPS device is not completely prepared for surveying, site location sketches are made inaccurately, site location is defined using GPS device, numerical data of the measurement are transferred to the computer, GPS surveying report is not printed, precision of surveying data is assessed, surveying data is processed by *GeoMap* software, digital and analogical topographic map at a scale M 1 : 500 does not meet the requirements of Geodesy and cartography technical regulations, a file is created not following the established procedure, the text in the file is unreadable in some places, insufficient presentation of a report, the most relevant processes are not explained.

The project paper makes up 20 percents of the total individual cumulative index (ICI).

REFERENCES AND OTHER SOURCES OF INFORMATION:

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	*(a tick-mark shall mean availability of the source)*		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	HARRY, L. *Landscape Surveying.* ISBN 9781111310608. 256 p.*	Department of Agricultural Engineering, Oklahoma State University, USA	√		√
4	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
5	2011	E., B., ЗОЛОТОВА; P., H., СКОГОРЕВА. *Геодезия с основами кадастра.* ISBN 978-5-904954-04-8, 978-5-8291-1246-2. 416 p.*	Академический Проект, Трикста	√		√
6	2011	NENORTAITĖ, Birutė Emilija; ir	Mastaičiai:			

		URBANAVIČIENĖ, Ilona. *Metodiniai nurodymai baigiamajam darbui rengti.* 38 p.	Kauno kolegija Geodezijos katedra			
Additional Reading						
1	1998	SKEIVALAS, Jonas. *Elektroniniai geodeziniai prietaisai* ISBN 9986-05-713-2. 193 p.	Technika	√		√
2	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
3	1992	TAMUTIS, Zigmas, et al. *Geodezija-1* ISBN 5-420-01331-2. 292 p.	Mokslo ir enciklope-dijų leidykla	√		√
4	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.* ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	Из датель-ство "Академи -ческий Проект"	√		√
5	2012	TORGE, WOLFGANG; MÜLLER, JÜRGEN. *Geodesy.* ISBN 978-3-11-020718-7. 539 p.*	University of Hannover, Germany.	√		√
6	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.08.01:2000: statybiniai inžineriniai geodeziniai tyrinėjimai*	Valstybinė geodezijos ir kartografijos tarnyba	√		√
7	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.11.02:2000: sutartiniai topografinių planų M 1:500, 1:1000, 1:2000 ir 1:5000 ženklai*	Valstybinė geodezijos ir kartografijos tarnyba			
8	2013	*AutoCad (Autodesk Product Design Suite for Education 2013)**				
Periodicals						
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.gpspartneris.lt				
4		http://www.infoera.lt				
5		http://www.geoportalas.lt				
6		http://www.gps.lt				
7		http://www.glonas-center.ru				

8		http://www.unavco.org				
9		http://www.navstar.com				
10		http://www.esa.int/esaNA/galileo.html				
11		http://www.gsb.lt				

*-references for international students

Prepared by assistant Vincas Zakarauskas

Appendix 1

KAUNO KOLEGIJA

UNIVERSITY OF APPLIED SCIENCES

FACULTY OF LANDSCAPING

DEPARTMENT OF GEODESY (12 pt, bold, *Times New Roman*)

NAME SURNAME (14 pt. *Times New Roman*)

PROJECT WORK TITLE

(18 pt bold, *Times New Roman*)

Project work

(12 pt, bold, *Times New Roman*)

Teacher **Name Surname**

(12 pt, bold, *Times New Roman*)

Mastaiciai,

2012

(12 pt, *Times New Roman*)

Appendix 2

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Educational Institution: Kauno Kolegija/University of Applied Sciences
Study Programme: Real Estate Measurement Engineering
Subject: Geodesy

TOPIC: GLOBAL POSITIONING SYSTEM (GPS),
WORLD GEODETIC SYSTEM *WGS 84.*

1. The Structure of the Topic: the analysis of topics *"Global positioning system (GPS)"* and "*World Geodetic System WGS 84*" covers analysis of GPS systems, GPS satellites, environmental effects on GPS surveying, GPS point positioning methods and World Geodetic System *WGS 84.*

2. The Length in Hours: 1 academic hour is envisaged for topic explanation.

3. The Innovative Methods Applied During Lectures for Topic Explanation: Presentation of information, discussions, case analysis, one-minute reflection, use of literature and material in virtual media (*Moodle*).

6. GLOBAL POSITIONING SYSTEM (GPS)

Global Positioning System (GPS) is a complex of special man-made Earth satellites and instruments for determination of spatial geodetic coordinates applying radio navigation method. There are navigational GPS instruments used for vehicles – aircrafts, space vehicles, ships, cars, and geodetic GPS instruments - used for specific constructions and kinematic measurements [1, 3].

There are two operational GPS systems in the world: american *NAVSTAR* and russian *GLONASS* navigation systems. *NAVSTAR* system was launched in 1983, *GLONASS* – in 1996.In 2011 two satellites of european navigation systems „*Galileo*"were launched and placed into circular orbit at 23 000 km. „*Galileo*" will be installed within the decade, and the first navigation signal will be transmitted to users in 2015, when sufficient number of satellites will be reached. By the year 2020 the constellation would consist of 27 active satellites and 3 spare satellites in orbit. Compared to U.S. GPS system satellites, „*Galileo*" is equipped with more precise atomic clocks – the most important component of the system [1]. The main *NAVSTAR* and *GLONASS* station parameters are provided in table 1.1..

Table 1.1.

The main components of *NAVSTAR* and *GLONASS* GPS systems

Indicators	*GLONASS*	*NAVSTAR*
Orbital altitude	19 100 km	20 200 km
Orbit inclination to equatorial plane	64,8°	55°
Orbital period	11 h 15 min 44 s	11 h 57 min 58,3 s
Number of Earth satellites	24	24
Time scale	UTC (Moscow)	GPS time
Coordinate system	PZ 90	WGS 84

Both GPS systems were invented for navigation. The systems are used to determine the location of objects on the earths surface and in the space around as well as motion vectors of the objects. These systems are also adapted for geodetic tasks: determination of point geocentric coordinates, Earth's gravity field parameters, geodetic constants and etc. *NAVSTAR* and *GLONASS* systems also deal with tasks related to geoid determination, Earth's pole movement, Earth's tides, geodynamics. High-precision geodetic networks are created with the help of these systems [1, 3].

GPS consists of segments: space, control and user segments. The space segment consists of 6 orbiting satellites placed so that not less than four satellites would elevate 10° higher above the horizon from any Earth's surface point and at any time of the day.

The precision of the point coordinates determined applying GPS method depends on the precision of clocks, satellite orbital parameters, signal parameter measurement accuracy, and satellite - user interlocation. Point geocentric coordinates *X, Y, Z* are determined according to absolute method with an error of several meters. Point coordinate changes in relation to another point location according to differential method are determined with an errors of several centimeters [1, 3].

6.1. GPS Satellites

Electronic technologies have opened the possibilities to create innovative Earth surveying methods: fast and accurate measurements. However, these methods are still limited by the density of control points, terrain ireguliarities and features. These restrictions are to be voided using man-made Earth satellites.

Nowadays the most advanced radio navigation system is the system operated by the U.S. Department of Defence (*DOD*). It is called the Global Positioning System - GPS (*NAVSTAR Global Positioning System*). GPS has been used since 1994 [1, 3].

GPS system consists of satellites orbiting above the earth's surface and ground-based stations (control segment). The satellites are placed in four orbital planes consisting of six satellites each. Each satellite transmits the exact time and location coordinates. A minimum of four satellites is required to determine the location of a point, however, more satellites ensure higher accuracy and faster detetermination of the coordinates. Satellite transmitted signals must be received simultaneously at the point the coordinates of which are being determined [2].

GPS satellites are placed at an altitute of approximately 20 200 km above the surface of the Earth. The precise orbital periods of the satellites are close to 11 hours 58 minutes. The satellite makes somewhat more than two orbits per day, therefore the same satellite may be seen from the same ground surface point twice a day. The satellite appears for the next time 4 minutes earlier than the day before. Each satellite has one transmitter and receiver, one antenna, five oscillators and one microcomputer. The oscillator uses rubidium and cesium frequency etalons. There may be less than 24 active satellites because of repair of single satellites. New satellites are launched if required.

Fig. 6.1. GPS staellites orbiting above the Earth

Ground-based GPS stations observe GPS satellites, monitor their position in space and the reliability. Satellite ephemeris data and time corrections are broadcasted from these stations to satellites. Satellites can use these corrections in its signals transmitted to GPS tools. There are five ground-based GPS satellite observation stations.

GPS has its own timing system - *GPS weeks* and *seconds of week*. The time is measured in GPS weeks, and the time of GPS week - in seconds of week, and this time varies from 1 to 604800. The GPS weeks begin at the Saturday/Sunday transition [1].

The aim of GPS method consists in measurement of the distance from the satellite to the receiver (trilateration). This distance is calculated according to the formula - the travel path of signal is equal to the multiplication of propagation speed and time. Point coordinates are calculated using special algorithms.

Time is an essential factor of the GPS system. Signals travel at the speed of light, so there is a high significance of any delay millisecond if converted into distance.

GPS operates with *WGS S4* coordinate system. User coordinates are converted into other coordinates providing corresponding specification [1, 3].

6.2. Environmental Effects on Surveying

The quality of GPS surveying is determined by the certain environmental factors:

- Ionospheric activity depends on the time of day and solar activity;
- Tropospheric propagation delay (depends on the satellite elevation angle);
- Signal obstacles (buildings, hills, trees, meter man);
- Signal reflections (the signal is reflected from a house or other object and then reaches the receiver - consequently the propagation distance is longer leading to the falsification of results);
- Radio wave interference (similar frequency radio wave sources). Ionosphere - the component of the Earth’s atmosphere from about 50 to 1 000 km altitude above the Earth’s surface. It consists of free electrons. Ionosphere has the greatest influence on GPS signals in northern and southern latitudes. Its activity is highly dependent on the 11-year sunspot cycle and the time of day (the greatest impact is on sunny day). 2000 - 2001 were the years of maximum solar activity. High solar activity can affect the initial determination of conditions for favorable surveying - drag out the measurement reducing the accuracy[1].

Tropospheric effect is simulated and eliminated by the GPS device. Determination of favorable conditions for surveying and the accuracy of measurements are influenced by tropospheric propagation delay. Where possible, the same height of base-type and portable device is set.

Obstacles around the receiver (houses, trees and etc.) limit the possibilities for the station to observe all satellites. They also increase the potential of signal reflection. Flat metal objects in the vicinity of the satellite antenna (roofs of cars) can cause signal reflection before the signal reaches the device. This may result in 1 to 5 centimeters measurement error [1, 3].

6.3. Number of Visible Satellites

GPS system is designed so that at leat four satellites were visible at every point of the Earth above any location on the horizon. But often more satellites are visible. Satellite inclination angle to the equatorial plane makes up 55°. The visibility of satellites depends on the point geographical latitude - the further north, the less satellites are observed simultaneously and the lower their elevation angle is. The maximum number of visible satellites is 12. When more satellites are seen, the surveyimng isfaster and the results are more accurate.

Satellite geometry directly affects the capabilities of GPS device. The best measurement conditions are when the angles of satellites are righter in respect to the device [1, 3].

6.4. Satellite Elevation Angle

GPS satellite orbit angle of inclination towards equator is approximatelly 55°, therefore the satillites will be never visible in the zenith further north than 55° of northern latitude and further south than 55° of southern latitude. Vilnius is approximatelly 54°38' of northen latitude therefore the satellites can be still observed in the zenith (right above the observer).

Why is the satellite elevation angle important? The quality of satellite transmitted signal depends on the elevation angle. The *elevation mask* is a very important and often used term in GPS science. It is the minimum satellite elevation angle that is visible above the user azimuth. It must be determined before measuring. If any of the satellites is lower of the set angle the signals from it will not be automatically received. Most often used minimum satellite elevation angle is 15°. It is the most suitable for a variaty of observations. When variable number of satellites is observed, e.g. five simultaneously, eight after a few seconds and again five or six, it means that some of the satellites are going down or up and are on the line of the set minimum elevation angle. In such case it is recommended to wait for some minutes till the fixed number of satellites or to change the minimum elevation angle and perform remeasuring [1, 3].

How does the elevation angle influence the accuracy of measurement? When the satellite elevation angle is small, the signal must travel longer path through the Earth's atmosphere from the satellite to the receiver. The Earth's atmosphere impedes signal propagation (because the light propagation is speeding down).

6.5. Point Positioning GPS Methods

Point positioning GPS method is chosen according to the requirements for accuracy and reliability of the set point location. GPS survey methods are the following: *Static*, *Reoccupation*, *Rapid Static*, *Kinematic*, *Stop&Go Kinematic*, *Real Time Kinematic -RTK, Differencial GPS* [1, 3].

Static method is the most precise and reliable. It is possible to coordinate with several devices at the same time during the measurement. Measurement time depends on the length of measured vectors, satellite observation possibilities, atmosphere conditions and other requirements. Such measurement may take from 30 minutes to several days. This method is often applied in measuring longer than 15 km vectors.

Reoccupation method is similar to the static, but the measurement at points takes less time i.e. 10 min., then continuing with the next point and going on to all set points before returning to the first one. Remeasurement with short time interval is performed. The advantage of this method is shorter measurement time.

Kinematic method is the most rapid. The measurement is performed in two established points applying Rapid Static method (approximately 5 min.). The advantage of the kinematic method is fast determination of point locations on the ground and in the space.

Stop&Go Kinematic method is a combination of Rapid Static and Kinematic methods. Measurements are performed without switching off the device, several minute stops are made at points for the reason of renewal of detection of the number of strong waves [1, 3].

The aim of Real Time Kinematic method is the same as of the simple Kinematic method. The main advantage of the Real Time Kinematic method consists in fast determination of poit locations because the measurement takes 5 - 10 seconds. Nowadays this method is the most applicable for point positioning. Corrections sent from the basic station located at the point with established coordinates are used in the cource of *RTK* measurement. The accuracy of *RTK* method makes up approximately 1 - 3 cm.

Differential methiod is a type of Real Time Kinematic method when the corrections from the established point are transmitted by radio waves from radio stations or broadcasted on the Internet.

The Real Time Point Positioning method is the post popular for real estate cadastral measurements.

6.6. World Geodetic System *WGS 84*

The locations of points have been determined with the help of GPS devices since 1984 according to the *World Geodetic System WGS* 84. It is a geocentric coordination system. Its geodetic datum coincide with the mass center of the Earth. *Z* axis is directed towards the conventional Earth's poles.

X axis is set according to *WGS* 84 prime meridian and conventional Earth's poles equator longitude. *WGS* 84 prime meridian is parallel to the zero meridian. *Y* axis is on the conventional Earth's pole equator longitude towards the east from *X* axis through 90°.

WGS 84 ellipsoid semi-major axis – 6 378137 m, longitude - 1 : 298,257 223 563. Ellipsoid geometry center coincide with *WGS* 84 coordinate system origin, and ellipsoid semi-minor axis - with axis *Z* axis of the coordinate system [2].

One-minute reflection questions

1. What are the world operational GPS systems?
2. What causes the most influence on the accuracy of GPS surveying?
3. When is the greatest impact of Ionosphere on GPS surveying?
4. Do the buildings influence the accuracy of GPS surveying ?
5. How long can the *RTK* method measurement take?
6. Could the Static method take 5 hours?
7. What is the axial meridian of the LKS -94 coordinate system?
8. What is the name of coordinate system where the origin of coordinates coincide with the mass center of the Earth?

General questions

1. Where are the GPS tools used?
2. What is the approximate height of satellites?
3. What coordinate system is used by *NAVSTAR* satellites?
4. Why does the surveying accuracy depend on orbital altitude?
5. What is the most often used minimum satellite elevation angle?
6. What is the most precise GPS surveying method?
7. What is the most common GPS method used for Real estate cadastral measurements?
8. What is the name of the world coordinate system?
9. What is the ellipsoid of the world coordinate system?
10. Is the WGS 84 coordinate system topocentric or geocentric?

- References and other sources of information:

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	(a tick-mark shall mean availability of the source)		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	Charles, D., GHILANI et al. *Elementary Surveying.* ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
Additional reading						
1	1998	SKEIVALAS, Jonas. *Elektroniniai geodeziniai prietaisai* ISBN 9986-05-713-2. 193 p.	Technika	√		√
2	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
3	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.* ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	Издатель-ство "Академи -ческий Проект"	√		√
4	2012	TORGE, WOLFGANG; MÜLLER, JÜRGEN. *Geodesy.* ISBN 978-3-11-020718-7. 539 p.*	University of Hannover, Germany.	√		√
5	2003	ERIK W. GRAFAREND, FRIEDRICH W. KRUMM, VOLKER S. SCHWARZE. *Geodesy – The Challenge of the 3rd Millennium.* ISBN-10: 3642077331. 487 p.*	Springer – Verlag Berlin Heidelberg	√		√
6	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.08.01:2000: statybiniai inžineriniai geodeziniai tyrinėjimai*	Valstybinė geodezijos ir kartografijos tarnyba	√		√
Periodicals						
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.gpspartneris.lt				
4		http://www.infoera.lt				
5		http://www.geoportalas.lt				

6		http://www.gps.lt				
7		http://www.glonas-center.ru				
8		http://www.unavco.org				
9		http://www.navstar.com				
10		http://www.esa.int/esaNA/galileo.html				
11		http://www.gsb.lt				

* references for international students

The topic of the Subject Programme prepared by: assistant Vincas Zakarauskas

Educational Institution: Kauno Kolegija/University of Applied Sciences

Study Programme: Real Estate Measurement Engineering

Subject: Geodesy

TOPIC: LITHUANIAN NATIONAL GEODETIC BASIS,
1994 LITHUANIAN COORDINATE SYSTEM - LKS 94,
DIRECT AND INVERSE ANGULAR INTERSECTION

1. The Structure of the Topic: the analysis of topics *Lithuanian National Geodetic Basis, 1994 Lithuanian Coordinate System - LKS 94, point coordination methods* covers the presentation and analysis of information regarding the structure of the Lithuanian National Geodetic Basis and its networks, LKS 94 coordinate system main data, coordinate reference point, essence of direct and inverse angular intersections, data processing procedure and permissible errors.

2. The Length in Hours: 2 academic hours are envisaged for topic explanation.

3. The Innovative Methods Applied During Lectures for Topic Explanation: Presentation of information, demonstration, discussions, one-minute reflection, individual tasks, case analysis, use of literature and material in virtual media (*Moodle*).

8. LITHUANIAN NATIONAL GEODETIC BASIS

The geodetic basis is required for real estate cadastral measurements, control, creation of topographic maps in the field of land cartography, construction, geodynamic investigations, state border marking and other activities requiring determination of point locations [1].

The Lithuanian Geodetic Basis consists of Lithuanian geodetic networks, their coordinates and heights. The totality of geodetic marks on the Earth's surface interconnected by geodetic surveying constitutes the geodetic network. The geodetic network is divided into national global positioning system (GPS), planimetric, vertical, gravimetric, magnetometer, permanent GPS station networks according to determinable parameters. According to the territory the geodetic networks and divided into world, continental, national, municipal, local and special networks [1].

The global positioning system of the Republic of Lithuania is the network of permanent reference GNSS stations called LitPOS. It is an information system of the Lithuanian National Geodetic Basis, which provides the users with geodetic control data in real time. LitPOS consists of 25 permanent reference GNSS stations located in the territory of the Republic of Lithuania. Regional GNSS station control room is equipped in Vilnius Gediminas Technical University. The purpose of LitPOS is to calculate and eliminate errors of GPS satellite signals received by GPS measurement tools and to determine the spatial location of objects on the Earth's surface in the territory of the Republic of Lithuania using GPS measurement equipment. The geodetic basis data corrected according to these errors is transmitted to LitPOS users through telecommunication facilities. LitPOS data source is GPS satellite signals received by permanent reference GNSS stations and transmitted through state safe data transmission network to LitPOS data processing centre. Other LitPOS data sources are the information from permanent reference GNSS stations, meteorological information, parameters of ionosphere model, parameter of the Lithuanian geodetic basis and Lithuanian geodetic coordinate system as well as parameters of related systems according to which the corrections for real time elimination of GPS satellite signal errors are calculated.

LitPOS activity functions: to receive GPS satellite signals throughout the Republic of Lithuania at uniformly located permanent reference GNSS stations and transmit the data through the state safe data transmission networks to LitPOS data processing centre; to process the LitPOS data and calculate corrections for real time elimination of GPS satellite signal errors; provide LitPOS users with corrected geodetic basis data using telecommunication tools. Organizational structure of LitPOS includes LitPOS administrator – National Land Service under the Ministry of Agriculture and LitPOS manager – state enterprise National Centre of Remote Sensing and Geoinformatics „GIS-Centras"; LitPOS users – physical and legal entities who uses GPS equipment for determination of object spatial location.

Physical and legal entities wishing to use the LitPOS data must fill in the registration on LitPOS web page www.nzt.lt, i. e. to fill in and send an electronic form of registration to LitPOS manager. After filling in and sending of the electronic form of registration the LitPOS manager provides physical and legal entities with LitPOS username, password and parameters of service station of the LitPOS data processing centre, providing geodetic basis data.

The requirements imposed on the LitPOS user for measurement by GPS equipment: capability to use Internet GPRS (eng. *General Packet Radio Service*) connection and capability to use Internet GPRS connection and receive RTK signals.

Planimetric network consists of: GPS, triangulation, polygonometry and local networks. GPS networks are divided into zero, first, second and third order networks. GPS network integrates 4 zero order, 52 first order, 1026 second order and 12 000 (1 station - 5 sq. km) third order stations.

Baltic height system is applied in Lithuania. Normal height is computed from Kronstadt zero (The Gulf of Finland) equipotential surface (geoid). Baltic system heights differ from Amsterdam system heights common for Europe by 15 cm.

The Lithuanian National Geodetic First Order Network consists of five closed polygons. Perimeter of the network is approximately 1900 km. Average perimeter of the polygon – 500 km, average distance between benchmarks and wall marks is approximately 1.5 km. Mean square error of one kilometre makes up 0.42 mm. Second order networks are placed inside and outside the first order polygons. The outside of the polygon is bounded by the border of the Republic of Lithuania. Vertical network stations in the territory of the country are located so as not to leave local points more than 15 km distant form first or second order stations. Average perimeter of the second order polygon is 120 km. Lengths of lines uniting network nodal points or reference points must not exceed 50 km.

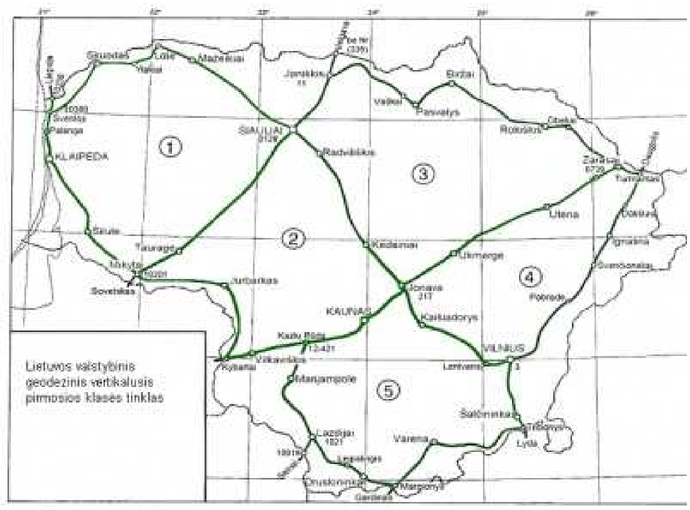


Fig. 8.1. Lithuanian National Geodetic Vertical First Order Network

The state geodetic network is also united by three absolute measurement stations and first order gravimetric network uniting 48 stations. A second order gravimetric network of 635 stations is created to carry out detailed geopotential field investigation in the territory of Lithuania. The gravimetric network is required to perform detailed gravity field investigations.

Lithuanian magnetometric network consists of 6 magnetometric stations equipped in the territory of Lithuania for determination of magnetic field ramp.

8.1. 1994 Lithuanian Coordinate System - LKS 94

1994 Lithuanian Coordinate System (LKS-94) integrated into the general European system only must be used since February 1, 1996. Coordinates of all the GPS (*Global Positioning System*) geodetic basis stations in the territory of Lithuania determined applying satellite method are located towards the global and geocentric mass centre of the Earth. Global geocentric coordinate system is WGS 84 (*World Geodetic System 1984*) with its realization in Europe EUREF 89 (*European Coordinate Referencing System* 1989) using GRS-80 (*Geodetic Reference System* 1980) ellipsoid.

LKS – 94 coordinate system includes:

– spatial coordinate system;

– normal gravity field and ellipsoid;

– planar coordinates system.

The spatial coordinate system aligns with *ETRS* 89 coordinates system of the united European geodetic network *EUREF* 89. It is a geocentric system. Location of a point is defined by rectangular coordinates *X, Y, Z*.

Normal gravity field and *GRS* 80 (*Geodetic Reference System*) ellipsoid.

Semi-major axis of the ellipse is a = 6378137 m, inverse flattening of the ellipse is – $1/f$= 298.257222101....

The centre of ellipsoid coincides with *ETRS* 89 system geodetic datum, or its semi-minor axis with *Z* axis.

Location of point is defined by geodetic latitude *B*, geodetic length *L* and geodetic (ellipsoid) height *He*.

Planar coordinate system is based on transverse cylindrical Mercator projection with axial meridian L_o = 24°C and projection scale at axial meridian m_o = 0,99980. Geodetic datum coincides with the intersection of axial meridian and equator on the plane of projection. Axial meridian projection is an abscissa (x) axis. Positive direction of this axis is directed toward the north. Positive direction of ordinates (y) axis is directed toward the east. The ordinate of abscissa axis is 500 000 m (Technical Regulation of Geodesy and Cartography. *GKTR 2.08.01:2000: engineering geodetic investigations for constructions*).

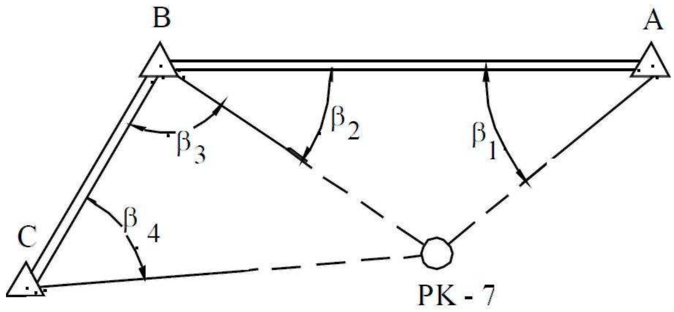
8.2. Point Coordination Methods

Coordinates of the locality point may be determined according to the geodetic intersection by measuring angles or lines. The intersection obtained as a result of measurement of angles is called angular intersection, and the result of measurement of a line is linear intersection. Angular intersections are divided into direct and inverse intersections and single or multiple depending on the number of measurements performed. The multiple intersection is more precise because of additional measurements and better controllable computations [1].

8.2.1. Direct Angular Intersection

In direct angular intersection the planimetric location of points *A*, *B* and *C* is known and angles β_1, β_2, β_3 and β_4 are measured. Coordinates of 7 picket point are calculated [1, 2].

The scheme of the direct angular intersection is provided in Fig. 8.1.



8.1. Scheme of direct angular intersection

Abscissa of 7 picket point is calculated according to the formula 8.1.:

$$x_{PK7} = \frac{x_A\, ctg\beta_2 + x_B\, ctg\beta_1 - y_A + y_B}{ctg\beta_2 + ctg\beta_1} \tag{8.1.}$$

Ordinate of 7 picket point is calculated:

$$x_{PK7} = \frac{y_A\, ctg\beta_2 + y_B\, ctg\beta_1 + x_A - x_B}{ctg\beta_2 + ctg\beta_1} \tag{8.2.}$$

Check calculation - abscissa:

$$x_{PK7} = \frac{x_A\, ctg\beta_2 + x_B\, ctg\beta_1 - y_A + y_B}{ctg\beta_2 + ctg\beta_1} \tag{8.3.}$$

Ordinate:

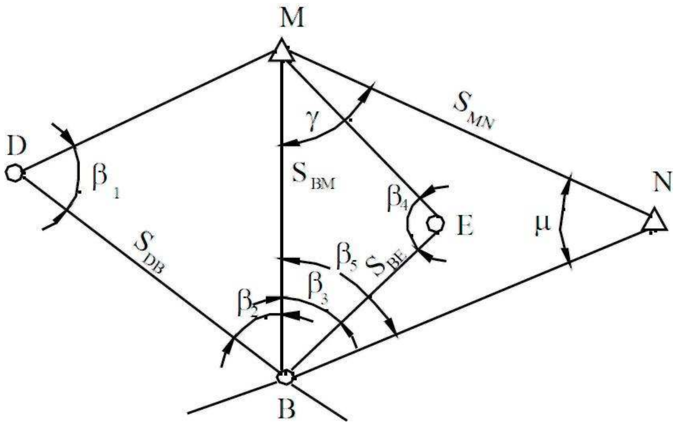
$$x_{PK7} = \frac{y_A\, ctg\beta_2 + y_B\, ctg\beta_1 + x_A - x_B}{ctg\beta_2 + ctg\beta_1} \tag{8.4.}$$

Difference of calculated coordinates not exceeding 50 cm is assumed.

8.2.2. Inverse Angular Intersection

The inverse angular intersection is calculated when coordinates of three points are known and the coordinates of the fourth point should be found. Two additional points must be selected, two datums must be created and lengths of datum lines must be measured in order to findthe coordinates of required point. Angles are measured between coordinated direction and datum lines.

The scheme of inverse geodetic intersection is provided in Fig. 8.2. [1, 2].



8.2. Coordinate displacement scheme

Coordinate displacement scheme is adapted to specific option according to the provided local directions. *DB* and *BE* datum lines must be drawn to ease the measurement of their lengths and angles.

The distance from point *M* to point *B* is calculated according to *DMB* and *EMB* triangles:

$$S_{BM} = \frac{S_{DB} \times \sin \beta_1}{\sin(\beta_{1} + \beta_{2})} \tag{8.5.}$$

$$S_{BM} = \frac{S_{BE} \times \sin \beta_4}{\sin(\beta_{3} + \beta_{4})} \tag{8.6.}$$

The result is positive if the difference between distances does not exceed 20 cm.

According to inverse geodetic task, direction angle and length of *MN* line are calculated:

$$arc\ \mathrm{tg}\alpha_{MN} = \frac{\Delta y_{MN}}{\Delta x_{MN}};$$

$$S_{MN} = \frac{\Delta x_{MN}}{\cos \alpha_{MN}};$$

$$S_{MN} = \frac{\Delta \mathrm{y}_{MN}}{\sin \alpha_{MN}};$$

$$S_{MN} = \sqrt{\Delta x^2 + \Delta y^2}.$$

Difference of distances not exceeding 20 cm is assumed.

μ and c values of angles are calculated:

$$\sin \mu = \frac{S_{BM} \times \sin \beta_5}{S_{MN}}; \quad (8.7.)$$

$$\gamma = 180^{o} - \beta_5 - \mu . \quad (8.8.)$$

The value of direction angle of *MN* line is calculated:

$$\alpha_{MB} = \alpha_{MN} + \gamma. \quad (8.9.)$$

According to direct geodetic task, coordinates of *B* point are calculated:

$$x_B = x_M + S_{BM} \times \cos \alpha_{MB}; \quad (8.10.)$$

$$y_B = y_M + S_{BM} \times \sin \alpha_{MB}; \quad (8.11.)$$

Direction angle of *BN* line is calculated:

$$arc\ \mathrm{tg}\alpha_{BN} = \frac{\Delta y_{BN}}{\Delta x_{bN}}; \quad (8.12.)$$

Check calculation of direction angle of *BN* line:

$$\alpha_{BN} = \alpha_{MB} + 180^{o} + \beta_5 .$$

The difference between values of direction angle of *BN* line must not exceed 5 seconds.

One-minute reflection questions

1. What networks do compose the Lithuanian Geodetic Basis?

2. What is the short name of the network of permanent reference GNSS stations of the Republic of Lithuania?

3. How many stations does the LitPOS network consist of?

4. What is the LitPOS administrator?

5. What is the LitPOS manager?

6. Who may use the LitPOS network?

7. What is the axial meridian of the LKS -94 coordinate system?

8. What is the projection scale at the axial meridian?

9. What is the name of the ellipsoid of LKS-94 coordinate system?

10. What are the check calculations performed for?

General questions

1. What is the web page where physical and legal entities must register to use the LitPOS data?

2. What does the planimetric network consist of?

3. What does the LKS – 94 coordinate system consist of?

4. What is the case for computation of inverse angular intersection?

5. What is the purpose of coordination of geodetic points?

6. What is the purpose of inverse geodetic task?

7. Characterize the purpose of direct angular intersection.

- References and other sources of information:

Se q. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	(a tick-mark shall mean availability of the source)		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
Additional reading						
1	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
2	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.08.01:2000: statybiniai inžineriniai geodeziniai tyrinėjimai*	Valstybinė geodezijos ir kartografijos tarnyba	√		√
Periodicals						
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.gpspartneris.lt				
3		http://www.infoera.lt				
4		http://www.geoportalas.lt				
5		http://www.gps.lt				
6		http://www.glonas-center.ru				
7		http://www.unavco.org				
8		http://www.navstar.com				
9		http://www.esa.int/esaNA/galileo.html				

* references for international students

The topic of the Subject Programme prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 1

TOPIC: LEVELING USING PRECISE DIGITAL LEVELS

1. The Aim of the Practical Work: to perform leveling and stakeout of points using a digital level, to analyse surveyed data.

2. The Objectives of the Practical Work: to describe digital levels, check and adjust precise digital level, to set registration of data in the memory of the level, to enter necessary data and settings in the memory of the device, to stakeout leveling line pickets, to perform standard precision leveling, to perform longitudinal leveling applying three methods, to level intermediate points, to process and analyse the surveyed data.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Key control and functions of the digital level are demonstrated, the tripod of level is set, the level is set up on the tripod, the device is set over the point, the level is levelled, eyepieces are adjusted, switch on/off of date registration is demonstrated, *Alpha* reference is adapted for leveling data entry, setting menu is described and demonstrated, leveling line pickets are set out, leveling line scheme is drawn, parameters required for leveling are entered (numbers of benchmarks, and measurements, order and sequence of numbering of pickets, the maximum		Key control and functions of the digital level are demonstrated, the tripod of level is set, the level is set up on the tripod, the device is set over the point, the level is levelled, eyepieces are adjusted, switch on/off of date registration is demonstrated, *Alpha* reference is adapted for leveling data entry, setting menu is described and demonstrated, leveling line pickets are set out, leveling line scheme is drawn, not all parameters required for leveling are entered (numbers of benchmarks, and measurements, order and sequence of numbering of pickets, the maximum		Key control and functions of the digital level are demonstrated, the tripod of level is set, the level is set up on the tripod, the device is set over the point, the level is levelled, eyepieces are adjusted, switch on/off of date registration is demonstrated, *Alpha* reference is adapted for leveling data entry, setting menu is described and demonstrated, leveling line pickets are set out, leveling line scheme is drawn, not all parameters required for leveling are entered (numbers of benchmarks, and measurements, order and sequence of numbering of		Key control and functions of the digital level are demonstrated, the tripod of level is set, the level is set up on the tripod, the device is set over the point, the level is levelled, eyepieces are adjusted, switch on/off of date registration is demonstrated, *Alpha* reference is adapted for leveling data entry, setting menu is described and demonstrated, leveling line pickets are set out, leveling line scheme is drawn, parameters required for leveling are			

permissible height variation measurement error on the station etc.), *Level 1* leveling is performed, intermediate points are measured, *Level 2* leveling and *Level 3* leveling are performed, measurement data is transferred to computer and revised, measurement data is printed and analysed.	permissible height variation measurement error on the station etc.), *Level 1* leveling is performed, intermediate points are measured, *Level 2* leveling and *Level 3* leveling are performed, measurement data is transferred to computer and revised, measurement data is printed and analysed.	pickets, the maximum permissible height variation measurement error on the station etc.), leveling applying two *Level* methods only is performed, intermediate points are measured, measurement data is not transferred to computer and not revised, measurement data is not printed and analysed.	not entered (numbers of benchmarks, and measurements, order and sequence of numbering of pickets, the maximum permissible height variation measurement error on the station etc.), leveling applying one *Level* method only is performed, intermediate points are not measured, measurement data is not transferred to computer and not revised, measurement data is not printed and analysed.

The teacher specifies the surveying object of the locality.

The survey is performed by groups of three or four students.

Each group selects a digital level from geodetic laboratory, prepares it for work using devise user manual and performs envisaged tasks.

Sequence of the practical work:

1. To demonstrate the key control and functions of the digital level.
2. To set a tripod of the level.
3. To set up the level on the tripod.
4. To set the device in the middle between the points.
5. To level the digital level.
6. To adjust the eyepieces.
7. To demonstrate the switch on/off of data registration.
8. To adapt *Alpha* reference for input of leveling benchmark data.
9. To describe and demonstrate the settings menu.
10. To set out leveling line pickets.
11. To draw leveling line scheme.
12. To enter parameters required for leveling (numbers of benchmarks, number of measurements, order and sequence of numbering of pickets, the maximum permissible height variation error on the station etc.).
13. To level the line applying *Level 1* pattern leveling.

14. To measure intermediate points.
15. To level the line applying *Level 2* pattern leveling.
16. To level the line applying *Level 3* pattern leveling.
17. To transfer measurement data to computer and perform review.
18. To print obtained data and evaluate survey results.
19. To prepare presentation of practical work.

***Level 1* pattern leveling**

The *Back Pn* prompt is displayed on the screen. Collimate to the rod *Backsight 1* and press *MEAS* key to recollect the measurement. When the measurement is completed the average value of the measurement is displayed on the screen. Message display time is set on the setting mode. When the setting mode is continuous measurement, press *ESC* key is pressed. The *Fore 1 Pn* message is on the screen. Point number is automatically increased.

Collimate to the rod *Foresight 1* and press *MEAS* to recollect the measurement. When the measurement is completed the average value of the measurement is displayed on the screen. Then collimation to the rod *foresight* in performed and *MEAS* key is pressed. *Foresight 2* measurement is performed in the same way. Collimation to the rod *Backsight 2* is performed. After the measurement has been completed the average value will be displayed. Further measurements are performed similarly to the process described for the first station.

Measurements on the1st station are displayed, see fig. 1.1. – 1.5.

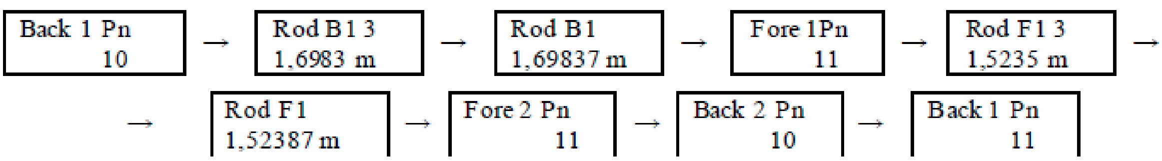


Fig. 1.1. Leveling procedure on the station according to *Level 1* pattern leveling

Collimation to the *Backsight* is performed. Leveling by the level is performed. Measurement is carried out. After *backsights 1* on the rod are taken the following screens are displayed, see fig. 1.2.

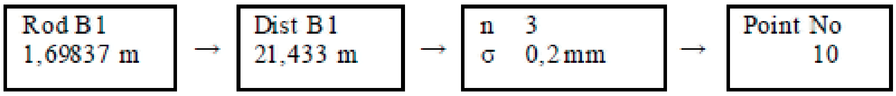


Fig. 1.2. *Backsight 1* reading data is on the screen

The following screens are displayed:

- average value of *backsight* readings – 1.69837 m;

- *backsight* distance to the rod– 21.433 m;

- n – total measurements taken - 3;

- σ – standard deviation – 0.2 mm;

- *backsight* point number - 10.

Further foresight rod readings are taken, Leveling by the level is performed and measurement is carried out. After the measurement to the *foresight 1* is completed, the following screens are displayed, see fig. 1.3.

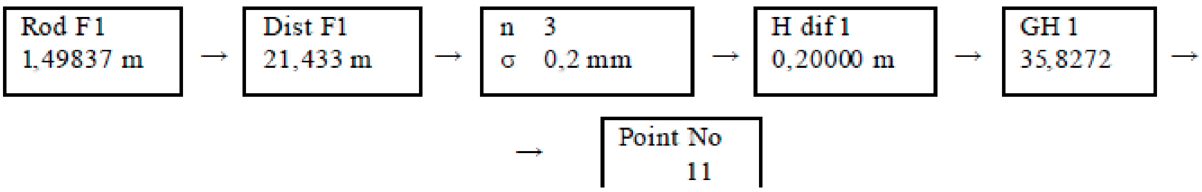


Fig. 1.3. *Foresight 1* reading data is on the screen

The following screens are displayed:

- average value of *foresight* readings – 1.49837 m;

- *foresight* distance to the rod – 21.433 m;

- n – total measurements taken - 3;

- σ – standard deviation – 0.2 mm;

- discrepancy of elevation *backsight 1* and *foresight 1*– 0.20000 m;

- *foresight* point elevation – 35.8272 m;

- *foresight* point number - 11.

After the measurement to the *foresight 2* is completed, the following screens are displayed, see fig. 1.4.

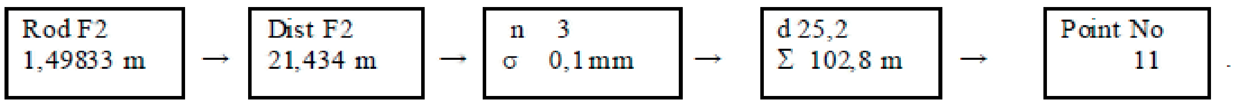


Fig. 1.4. *Foresight 2* reading data is on the screen

The following screens are displayed:

- average value of *foresight* readings – 1.49833 m;
- *foresight* distance to the rod – 21.434 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.1 mm;
- d - total *backsight* distance – total *foresight* distance;
- Σ - total *backsight* distance + total *foresight* distance;
- *foresight* point number - 11.

Backsight on the rod is taken, leveling by the level is performed and measurement is carried out. After the measurement to the *backsight 2* is completed, the following screens are displayed, see fig. 1.5.

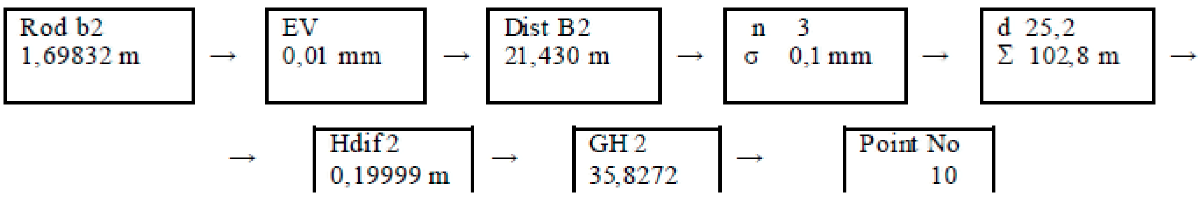


Fig. 1.5. *Backsight 2* reading data is on the screen

The following screens are displayed:

- average value of *backsight* readings – 1.69832 m;
- height difference error - (*backsight 1 – foresight 1*) – (*backsight 2 – foresight 2*) – 0.01 mm;
- *backsight* distance to the rod – 21.430 m;

- n – total measurements taken - 3;

- σ – standard deviation – 0.1 mm;

- d - total *backsight* distance – total *foresight* distance;

- Σ - total *backsight* distance + total *foresight* distance;

- discrepancy of elevations *backsight 2* and *foresight 2* - 0.19999 m;

- *backsight* point elevation – 35.8272 m;

- *backsight* point number - 10.

Level 2 **pattern leveling**

The procedure of measurement is provided in fig. 1.6.

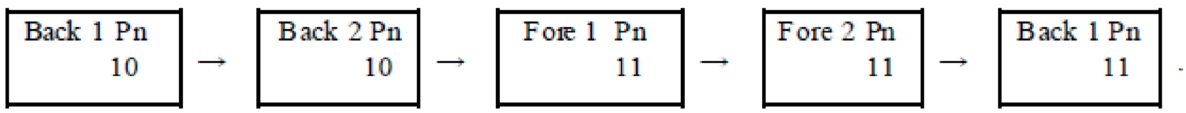


Fig. 1.6. Leveling procedure on the station according to *Level 2* pattern leveling

Measurement procedure:

1. *Backsight 1* on the rod is taken.
2. *MEAS* key is pressed.
3. *Backsight 2* on the rod is taken.
4. *MEAS* key is pressed.
5. *Foresight 1* on the rod is taken and *MEAS* key is pressed.
6. *Foresight 2* on the rod is taken.

The same method is applied to further measurements.

After the first measurement to the *backsight 1* is completed, the following screens are displayed, see fig. 1.7.

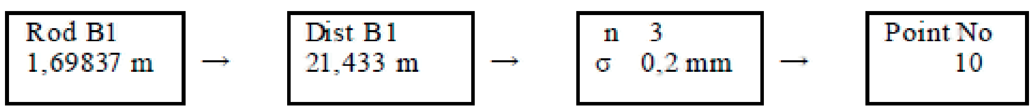


Fig. 1.7. *Backsight 1* reading data is on the screen

The following screens are displayed:

- average value of *backsight* readings – 1.69837 m;
- *backsight* distance to the rod – 21.433 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.2 mm;
- *backsight* point number - 10.

After the second measurement to the *backsight 2* is completed, the following screens are displayed, see fig. 1.8.

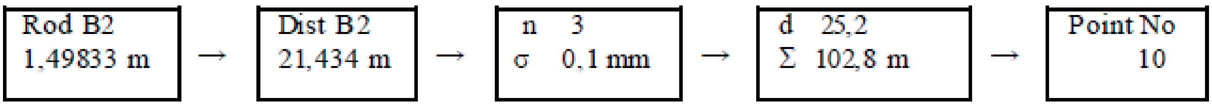


Fig. 1.8. *Backsight 2* reading data is on the screen

The following screens are displayed:

- average value of *backsight* readings – 1.49833 m;
- *backsight* distance to the rod – 21.434 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.1 mm;
- d - total *backsight* distance – total *foresight* distance;
- Σ - total *backsight* distance + total *foresight* distance;
- *backsight* point number - 10.

Foresight rod readings are taken, Leveling by the level is performed, measurement is carried out.

After the measurement to the *foresight 1* is completed, the following screens are displayed, see fig. 1.9.

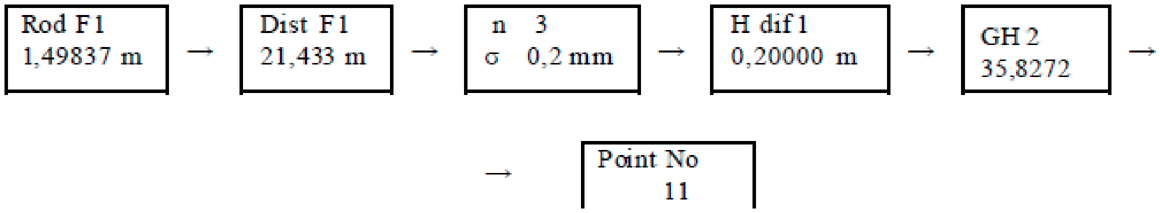


Fig. 1.9. *Foresight 1* reading data is on the screen

The following screens are displayed:

- average value of *foresight* readings – 1.49837 m;

- *foresight* distance to the rod – 21.433 m;

- n – total measurements taken - 3;

- σ – standard deviation – 0.2 mm;

- discrepancy of elevations between points *backsight 1* and *foresight 1* – 0.20000 m;

- *foresight* point elevation – 35.8272 m;

- *foresight* point elevation - 11.

The second *foresight 2* on the rod is taken. After the measurement to the *foresight 2* is completed**,** the following screens are displayed, see fig. 1.10.

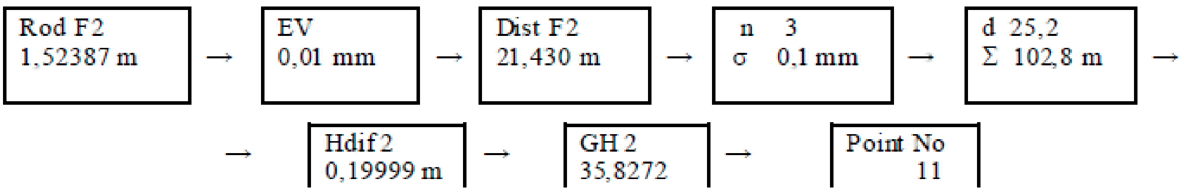


Fig. 1.10. *Foresight 2* reading data is on the screen

The following screens are displayed:

- average value of *foresight* readings – 1.52387 m;

- difference error - (*backsight 1 – foresight 1*) – (*backsight 2 – foresight 2*) – 0.01 mm;

- *foresight* distance to the rod – 21.430 m;

- n – total measurements taken - 3;

- σ – standard deviation – 0.1 mm;

- d - total *backsight* distance – total *foresight* distance;

- Σ - total *backsight* distance + total *foresight* distance;

- discrepancy of elevations *backsight 2* and *foresight 2*– 0.19999 m;

- *foresight* point elevation – 35.8272 m;

- *foresight* point number - 11.

***Level 3* pattern leveling**

The *Back Pn* prompt is displayed on the screen. The procedure of the measurement is provided in fig. 1.11.

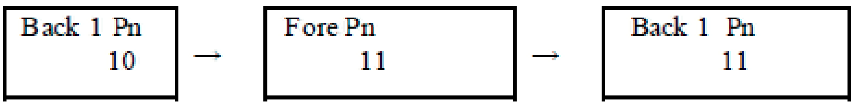


Fig. 1.11. Leveling procedure on the station according to *Level 3* pattern leveling

Measurement procedure:

1. *Backsight* on the rod is taken.
2. *MEAS* key is pressed.
3. *Foresight* on the rod is taken.
4. *MEAS* key is pressed.

The same method is applied to further measurements.

After the measurement to the *backsight* is completed, the following screens are displayed, see fig. 1.12.

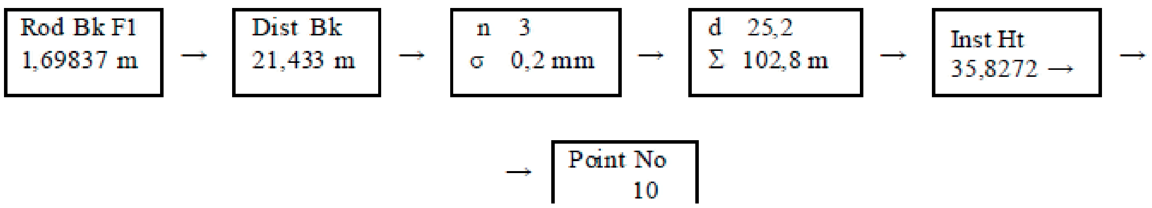


Fig. 1.12. *Backsight* reading data is on the screen

The following screens are displayed:

- average value of *backsight* readings – 1.69837 m;
- *backsight* distance to the rod – 21.433 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.2 mm;
- horizon of instrument – 35.8272 m;
- *backsight* point number - 10.

Foresight rod reading are taken, leveling is performed, measurement is carried out.

After the measurement to the *foresights* is completed, the following screens are displayed, see fig. 1.13.

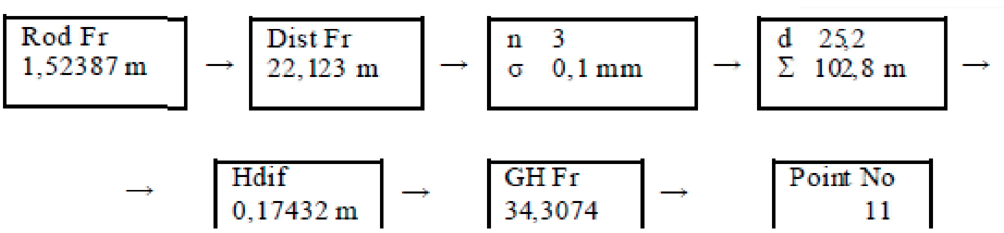


Fig. 1.13. *Foresight* reading data is on the screen

The following screens are displayed:

- average value of *foresight* readings – 1.52387 m;
- *foresight* distance to the rod – 22.123 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.1 mm;
- d - total *backsight* distance – total *foresight* distance;
- Σ - total *backsight* distance + total *foresight* distance;
- discrepancy of elevation *backsight* and *foresight*– 0.17432 m;
- *foresight* point elevation – 34.3074 m;
- *foresight* point number - 11.

Measurement of intermediate points

IN/SO key is used to measure intermediate points.

Number of measurements is selected, three measurements are selected for the given case.

The procedure of measurement of intermediate points is provided in fig. 1.14.

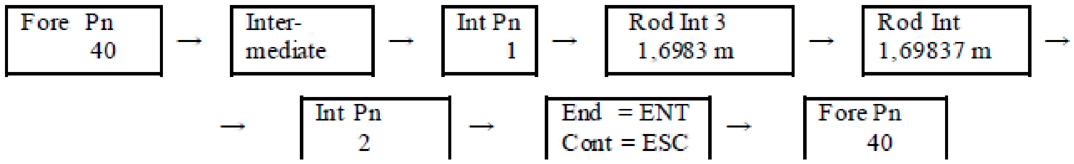


Fig. 1.14. Measurement of intermediate points

1. After completing the measurement to the *backsight* and before measuring to the next *foresight* press the *IN/SO* key.

2. Press the *ENT* key. The instrument is now ready to collect the measurement to the intermediate point, the *Inter – Mediate* prompt is displayed on the screen.

3. Collimate to the instrument on the staff which should be set on the intermediate point and press the *MEAS* key.

4. Measured average height is displayed after the measurement. Other values are available by pressing the [▲] and [▼] keys.

5. Press the *ESC* key. The instrument is ready to collect the next intermediate point. The intermediate point number is automatically increased or decreased.

6. Repeat steps for each intermediate shot.

Review of intermediate points is possible. Measurement data of the intermediate point is provide in fig. 1.15.

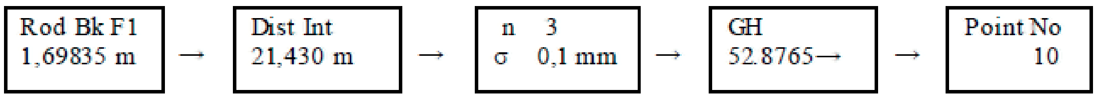


Fig. 1.15. Intermediate point measurement data

The following screens are displayed:

- average value of intermediate point readings – 1.69835 m;
- distance to the rod – 21.430 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.1 mm;
- intermediate point elevation – 52.8765 m;

- number of intermediate point - 10.

The end change point *End Mode*

It is possible to stop the Leveling at the intermediate point and later proceed with measurement. The stop of measurement is provided in fig. 1.16.

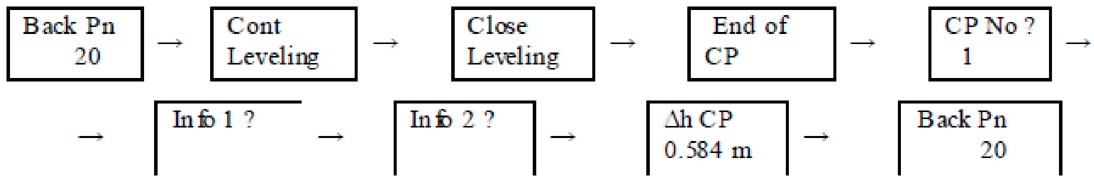


Fig. 1.16. Measurement stop at the intermediate point

Measurement procedure:

1. Press the *MENU* key at the “*Back Pn*” prompt after having collected a *foresight* point and before measuring a *backsight* point.

2. Press the [▲] key to display the *Menu* and *End Mode* menu.

3. Press the *ENT* key twice. Enter remarks, if required, at the *Info 1* prompt, press the *ENT* key. If there were no intermediate points, the distance difference between benchmarks will be shown. Input is limited to 16 alphanumeric characters. If record mode is *OFF*, this step is skipped.

3. Press the *ENT* key.

A fragment of measurements data is provided in fig. 1.17.

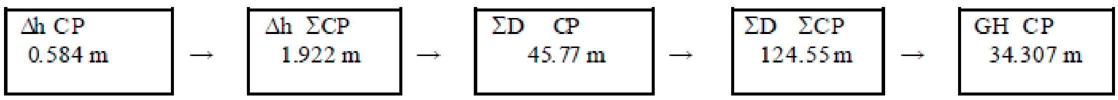


Fig. 1.17. Measurement data

To look through the measurement data press the [▲] or [▼] keys. Displayed data:

- height difference between benchmark and the end change point – 1.922 m;
- horizontal distance from the end change point – 45.77 m;
- distance from the benchmark to the end change point – 124.55 m;
- elevation of the end change point – 34.307 m.

Set out of points

The data of set out point can be taken from *RAM* or from memory card according to the *Out module* setting. The selected number of measurements – three. The procedure of point set out is provided in fig. 1.18.

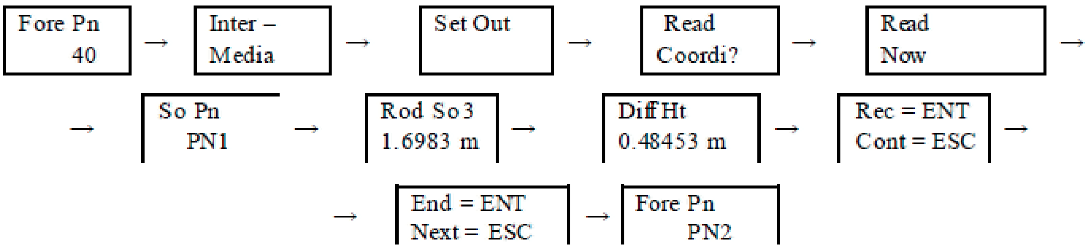


Fig. 1.18. Point set out procedure

The procedure of point set out:

1. After *backsight* measurement and prior to *foresight* measurement the *IN/SO* key is pressed.

2. *Setout menu* is selected by pressing [▲] or [▼] keys.

3. *ENT* key is pressed. The data is taken from *RAM* of from the *Group*, depending of the selection in *Out module* settings.

4. Press the *ENT* key.

5. Press [▲] or [▼] keys to select the point and then press the *ENT* key.

6. To look through the altitudes and note screens press [▲] or [▼] keys.

7. A sight on the rod set up on the set out point is taken and the *MEAS* key is pressed. After measurement an information with three measured values and final average value of the measurement will be displayed.

8. To save measurement data press the *ENT* key.

9. To measure set out point press the *ESC* l key.

10. Return to the *Fore Pn* message box by pressing the *ENT* key.

11. For next point set out press the *ESC* key.

12. After the sight on the rod, other information is available by pressing [▲] or [▼] and *MEAS* keys.

The measurement data of set out point is provided in fig. 1.19.

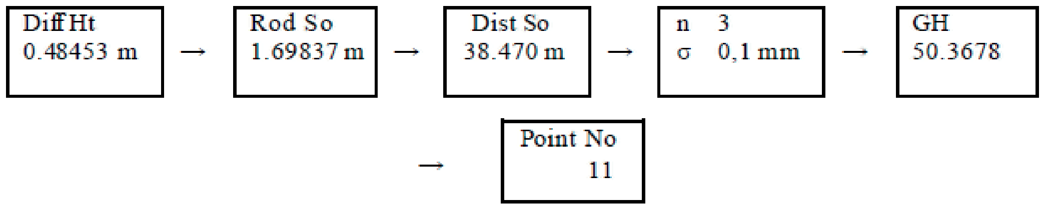


Fig. 1.19. Set out point measurement data

The following screens are displayed:

- average value of height difference – 0.48453 m;
- horizontal distance from the level to the set out point – 38.470 m;
- n – total measurements taken - 3;
- σ – standard deviation – 0.1 mm;
- set out point elevation – 50.3678 m;
- number of the set out point - 11.

ADDITIONAL MATERIAL FOR COMPLETION OF THE PRACTICAL WORK

Key function of the digital level *DL-102C* are provided in table 1.1., and table 1.2. provides for display contents of the digital level *DL-102C.*

Table 1.1.

Key functions of digit level *DL-102C*

Keys	Functions
REC	Records the measured data or enters the displayed data to the instrument
SET MENU	Initiates Set mode and Menu mode
SRCH	Data search
IN / SO	This key is used to initiate intermediate point or set-out mode collection during line leveling
DIST	Distance measurement
MANU	Manual key used to input the data from the keyboard
▼ ▲	This key is used to page through menu screens or data display screens
◄ ►	If the displayed value overflows the screen this key can be used to shift the display to the right or left in the screen
REP	This key is used to remeasure the previous backsight or foresight point during line leveling
ESC / C	This key can be used to escape from the menu mode or any of the setting modes. This key can be used as a backspace key when inputting data
O < 9	These keys are used to input numeric values
. (▼)	When in alpha mode this key will change between numeric, alpha, or symbol

	input mode
- [ ]	This key can be used to measure with a inverse staff. Inverse staff mode is necessary to set "USE" within the set mode beforehand
ENT	Use this key to confirm mode parameters and to enter displayed data values
MEAS	This key is used to initiate a measurement
POWER	This key is used to cut the instrument ON or OFF

Table 1.2.

DL-102C level display contents

Display	Contents
REC	Indicate the record mode is on
i	Inverse measurement mode
So	Set out mode
BM	Benchmark
Bk	*Backsight*
Fr	*Foresight*
Int	Intermediate point measurement, sideshot
↕	Pressing ▼ or ▲ keys to display the next menu
Inst Ht	Instrument height
CP	Changing point
GH	Ground height

Setting of record mode. To store the measured data to the internal memory of the instrument the *Set Mode* should be set. *Out Module* has to be set to *RAM* or *Card*.

Module *RAM*: the measured data is stored in the instrument *RAM*. Maximum 8000 point data can be stored in *RAM*, maximum – 256 jobs. *Group* cannot be made within *RAM*.

Module *Card*: the measured data can be stored in Memory card directly, maximum – 256 groups.

Module *RS-232C*: Connect *DL-101C/102C* to external device and output the data every time measured. The measurement in this mode can be Standard Measurement (*Menu Measure*) only.

Module off: the measured data is displayed only but not stored or output.

Entering characters when in *Alpha* mode. When record mode is on, alphanumeric characters can be entered when entering fields such as remarks. Small letters and symbol marks can be input only in input of Remarks (*Info1,...*). In other input, only capital letters and numeric characters can be input.
The word *RAM* cannot be used for the group name. For the group name (only for card) only capital letters, numeric characters and " – " can be input (maximum 8 characters). For the job name capital letters, numeric characters and " – " can be input (maximum 8 characters).
For the Info capital and small letters, numeric characters and all symbol marks can be input (maximum 16 characters).

Example: Enter *Tp#7*. Operating procedure:

1. The „*Info 1* ?“ prompt is displayed on the instrument screen.

2. Press the [▼] key to enter the capital alphabet letter mode. Part of English alphabet is displayed.

3. Press the [◄] or [►] key until the letter “*T”* is located at the flashing cursor.

4. Press the *[ENT]* key. The “*T*” is entered and displayed on the bottom line.

5. Press the [▼] or [▲] key to enter the small letter mode.

6. Press the [◄] or [►] key several times until “*p*” is located at the flashing cursor. Press the *[ENT]* key.

7. Press the [▼] or [▲] key to enter the symbol mode.

8. Press the [◄] or [►] key several times until *“#*” character is located at the flashing cursor. Press the *[ENT]* key.

9. Press the [▼] or [▲] key to enter the numeric mode.

10. Press the [◄] or [►] several times until the “*7*” character is located at the flashing cursor. Press the *[ENT]* key.

11. Press the *[ESC]* key.

12. Press the *[ENT]* key after confirming the contents of the displayed string.

Input is limited to 8 characters.

Set mode. The set mode menu allows the user to select a variety of different options that affect the way the level operates. The set menu allows the user to select measuring units, communication parameters, etc. The settings remain unchanged even when the power is off.

Press the *[SET]* key and the *Set Mode* will be displayed in context menu. Press the *[ENT]* key to select the displayed option.

Available settings:

1. ***Check Battery*** **–** displays the battery voltage. The battery icon displays the battery capacity. No light: the battery level is sufficient for measuring; light: measuring is possible but the battery is partly discharged; flash: a flashing indicates the battery will soon be discharged. Charge to a new battery as soon as possible.

Using one of the *Set menu* options battery voltage level is checked. Before the measurement or while the screen displays the *MENU*, press the *[SET]* key and the *Check Battery* message will be displayed. Press the *[ENT]* key and the battery voltage level will be displayed. Press the *[ESC]* key and the message that was displayed before pressing the *[SET]* key will be displayed.

2. ***Set Measure*** **–** measurement method: continuous, single, n **–** times.

- *Measure N Time* – number of measurements is between 2 and 99.

- *Measure Single* – single measurement mode.

- *Measure Cont* – continuous measurement mode.

3. ***Set Fix*** – set the minimum units read by the level.

- *Fix Standard – DL-101C level* – 0.1 mm, DL – 102C – 1 mm.

- *Fix Precise DL 101C level* – 0. 01 mm, DL– 102C – 0.1 mm.

4. ***Set Item*** – set standard or extended data display in line leveling. You may select standard or extended data display. Extended data: *d:* total backsight distance – total foresight distance; Σ*:* total backsight distance + total foresight distance;

- *Item Standard* – do not display extended data;

- *Item Extended* – display extended data.

5. ***Display Time*** – setting display duration. This option is used to set how long certain screens will be displayed before the next screen is displayed. *Select N Sec.* – set the display duration in seconds, 1-9 secs.

6 .***Display Unit*** – setting distance units.

- *Unit m* – meters (m).

- *Unit ft* – feet (ft).

7. *Out Module –RAM* data storing, *RS-232C* or OFF. Option that determines if and where the data will be stored.

- *Ram* – measured data is stored to internal memory.

- *Card* – measured data is stored to memory card.

- *RS-232C* – communication with an external data collector is enabled.

- *Off* – measured data is not stored.

8. *Point Number* – selection of point number increase or decrease.

9. *File Out* – sending a data file.

10 . *Set Comm* – communication parameters.

11. *Auto Cutoff* – auto cut off is on or off. If *Auto Cutoff* is *ON*, the instrument will automatically cut off after 5 minutes, if none of the keys will be pressed during these 5 minutes.

12. *Set Bright* - used to change the brightness of the display. The *brightness* can be set to one of nine different settings.

13. *Set Light* – this option is used to turn the back light ON or OFF.

14. *Check Time* – display and edit the date and time.

15. *Inverse Mode* – used to measure with the inverted rod.

- *Inverse Not Use* – Not use the Inverse Mode;

- *Inverse Use* – Use the Inverse Mode.

16. *Swing Correct* – determines whether Swing Correct is on or off.

Changing set modes. Press the *[SET]* key while either in menu mode or before measuring. The *Set Mode* screen will be displayed for a few seconds and then *Check Battery* will be displayed. Press [▲] or [▼] key several times until displays *Set Measure* screen. Select the measurement mode by pressing [▲] or [▼] keys. Press *[ENT]* key and set the measurement times by inputting numerical character and press the *[ENT]* key. The display returns to *Set Measure*.

Standard measurement *Menu meas.* Examples of the practical work are carried out using digital level *DL-102C*.

Standard measurement mode is used to take measurements without having an elevation calculated. If *Out Module* is set to *Ram* or *Card*, you will be prompted to enter remarks and job number, and all measurements will be recorded to instrument memory. Measurement procedure: recording mode is *ON*, three measurements are performed. „*Menu Measure*“ prompt is displayed.

- Press the *ENT* key.

- Enter the *job No.* and press *ENT*. Maximum 8 characters allowed in field *JobNo*, and 16 characters in Remarks.

- Enter the *MeasNo* and press the *ENT*. To bypass the remark prompts and go directly to the next step press *ENT* at the "*Info 1*" or "*Info 2*" prompt. Maximum of 8 numerical characters can be input in *MeasNo*. The job no., measuring no., and remarks are not entered when the record mode is of record mode is OFF.

- Collimation to the rod is performed and the *MEAS* key is pressed. Three measurements will be taken and the average value will be displayed. If the level is set for continuous measuring, press the *ESC* key. The screen then displays the last measured data.

When measurements are completed the information is displayed. Press the [▲] or [▼] key to view the alternate screens. Press the *REC* key to store the data.

Display when [▲] or [▼] key is pressed:

- *Rod Avg 1,69837* – *n* – times measurement height difference average value.

- *Dist Avg 23,427 m* – distance to the rod.

- *n 3* – number of measurements.

- σ *0,2 mm* - standard deviation.

- *Meas Pn 4* – point number display.

Record mode (*Out Module*) must be set to *RAM*, *Card* or *OFF* to run line leveling. The example in this chapter assumes that record mode is set to *RAM*. If the line leveling data is saved into Data card directly, *Out Module* must be set to *Card*.

- *Menu Leveling* – start of line leveling.
- *Start Leveling* – input *Job No*, benchmarks and remarks.
- *Cont Leveling* – leveling sequence. There are three patterns of line leveling as follows:

1. *Level1 (Method 1): backsight 1 → foresight 1 → foresight 2 → backsight 2.*
2. *Level 2 (Method 2): backsight 1 → backsight 2 → foresight 1 → foresight 2.*
3. *Level 3 (Method 3): backsight → foresight*

The following keys can be used during measurements:

- *REP*: remeasure the foresight or backsight;
- *MENU*: manual entry of rod height and rod distance;
- *DIST*: measure a distance;
- *INT/SO:* intermediate point collection (*Intermediate*)/Set out measuring (*Set out*).
- *Close Leveling* – to end the measurement.

Start of line leveling. Start of line leveling *Start L* is used to enter the job no., benchmark no., and benchmark elevation. After this data has been entered the measurement to the *backsight* is taken. Start of line leveling is provided in fig. 1.20.

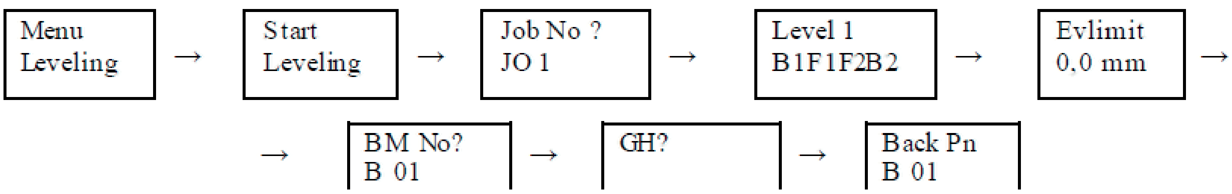


Fig. 1.20. Start of line leveling

Measurements are started from *backsight* station.

Procedure:

1. Press the *ENT* key.
2. Press the *ENT* key. The previously used job number will be displayed as the default.

3. Enter *Job No.*, and press *ENT*. When record mode is off (*Out Module* is *OFF*), the input of job no., benchmark no. and remarks is bypassed.

4. Select a measuring pattern of line leveling by pressing the [▲] or [▼] and press the *ENT* key.

5. Enter the limit of discrepancy (*EV limit*) and press the *ENT* key. When *Level 3 (backsight → foresight)* is selected, the input of limit of discrepancy is bypassed.

6. Enter benchmark No. and press the *ENT* key. When record mode is off (*Out Module* is *OFF*), the input of job no., benchmark no. and remarks is bypassed.

7. Enter benchmark elevation and press the *ENT* key.

8. Enter remarks and press the *ENT* key. To bypass the remark prompts and go directly to the next step press *ENT* at the *Info 1* or *Info 2* prompt. Screen displays measurement of *backsight* point (benchmark).

Point number modifying

Point number can be changed before *foresight* measurement (fig. 1.21.). In point number, numeric characters and the capital letter alphabets and " - " are usable to 8 characters. The point number used once can be used again.

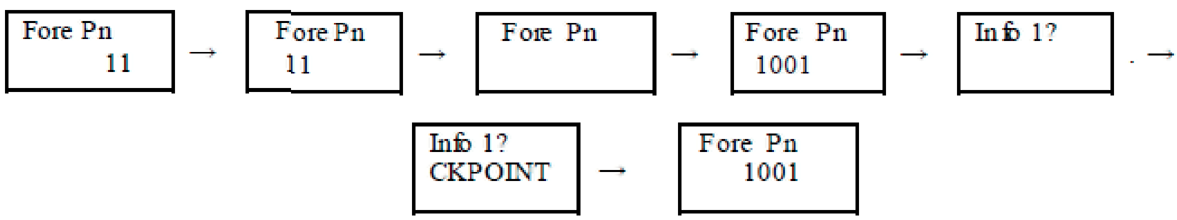


Fig. 1.21. Point number modifying

The *Fore Pn 11* is displayed. Press the *ESC* key before foresight measurement. The point number moves to the left side. Press the *ESC (C)* key twice to clear the number. The *Fore Pn* prompt will be displayed – point number will be cleared.

New point number is entered. For example, *1001*; *Fore Pn 1001* will be displayed. Input is limited to 8 alphanumeric characters. In the same line leveling, the point number used already can be input. The *ENT* key is pressed. *Info1 ?* prompt is displayed for remark entering. Enter the remark and press the *ENT* key. Input is limited to 16 alphanumeric characters. Example: *CKPOINT*, (displayed: *Info1 ? CKPOINT*).

By pressing the *ENT* key, Point number will be changed to – *Fore Pn1001*.

It is possible to set up auto increment, auto decrement.

If there is numeric character at the end of the point number which it was input into in the last time, point number of this time is indicated with last value+1.

When overall length of point number is less than 8 characters, digit sequence will shift right, and increase by 1 figure. Example: last time - ABCD-99, this time - ABCD-100.

When overall length of point number is 8 characters. Figure shift is ignored. Example: last time - ABCDE-99, this time - ABCDE-00.

If there is numeric character at the end of the point number which it was input into in the last time, point number of this time is indicated with last value - 1.

Numeric character is decreased by 1 in case of more than 1. Example: last time - ABC-02, this time - ABC-01, next time - ABC-00.

When numeric character section is 0 entirely, " 9 " are indicated till overall length is 8 figure. Example: last time - ABC-00, this time - ABC-9999, next time - ABC-9998.

Repeat measurements

The *REP* key is used to recollect either the previous *backsight* or *foresight* point in the event that the point was collected in error. The data which stored before remeasuring, will not affected on the result of each data calculations.

***Level 1* measurements.** After finishing *backsight 1* or *foresight 1* measurement, it is possible to remeasure from *backsight 1*. After finishing *backsight 2* or *foresight 2* measurement, it is possible to remeasure from *foresight 2* or *backsight 1*.

***Level 2* measurements.** After finishing *backsight 1* or *backsight 2* measurement, it is possible to remeasure from *backsight*. After finishing *backsight 1* or *foresight 2* measurement it is possible to remeasure from *foresight 1* or *backsight 1*.

***Level 3* measurements.** After finishing *backsight* measurement it is possible to remeasure from *backsight.* After finishing *foresight* measurement, it is possible to remeasure from *foresight* or *backsight.*

Remeasurement form *backsight 1,* after the *foresight* measurement by *Level1* method is finished, is provided in fig. 1.22.

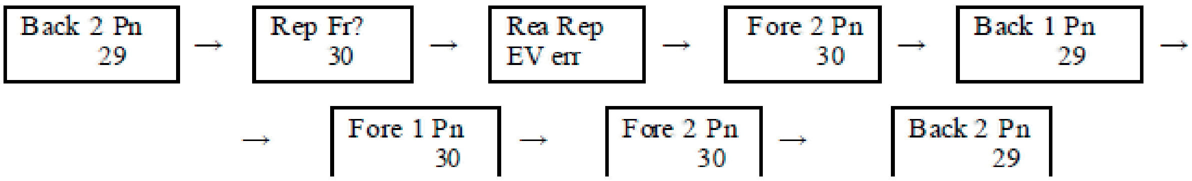


Fig. 1.22. Remeasurement applying *Level 1* method

Remeasurement procedure:

1. Press the *REP* key at the *REP Back2Pn* prompt.

2. Press the [▲] or [▼] key to view the measured data.

3. The *Back2Pn 29* prompt is displayed, press the *REP* key, the *Rep Fr? 30* enquiry appears – do you wish to recollect the measurement?

4. Press the *ENT* key to confirm that you wish to recollect the measurement *Rea Rep EV err*.

5. Press the [▲] or [▼] key to select a remeasurement reason and press the *ENT* key. You can select one of the following 3 reasons:

- OP err: operation error;
- EV err: discrepancy of elevation error;
- RD: reading error.

6. Press the *REP* key again. The display returns to the *Back 1 Pn* prompt.

7. Collimate to the *foresight Fore1Pn 30* and press *MEAS* to recollect the measurement.

8. When the measurement is completed the measured data is displayed on the screen.

9. Collimate to the *backsight* and press *MEAS* to recollect the measurement.

10. The display returns to *Back2Pn* prompt. Press the [▲] or [▼] key to display the final measured point.

End of line leveling (end of benchmark) *End Mode*

Used for measurement completion. The end of line leveling is provided in fig. 1.23.

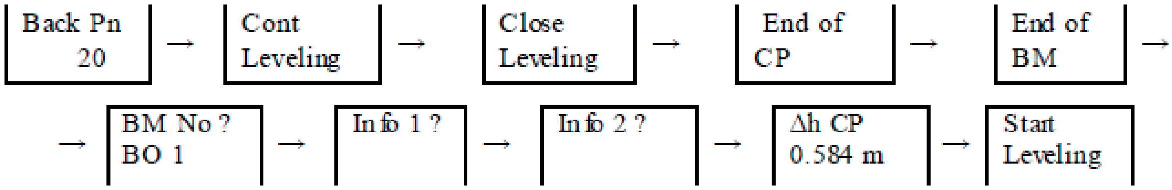


Fig. 1.23. End of line leveling

Measurement procedure:

- Press the *MENU* key after having collected a *foresight* point and before measuring a *backsight* point;

- press the [▲],key to display the *Menu* and *End Mode* prompts;

- press the *ENT* key*;*

- press the [▼] key to display the end of benchmark screen *End of BM*;

- press the *ENT* key*;*

- enter the ending benchmark number and press the *ENT* key;

- enter to remarks if required;

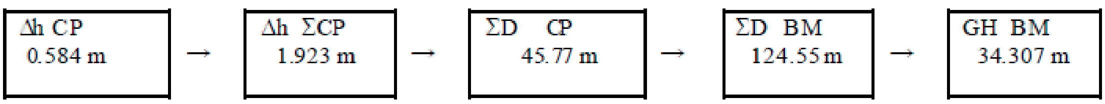
- press *ENT* at the *Info1* prompt to bypass remark entry. Input is limited to 16 alphanumeric characters. If *REC Mode* is *OFF*, this step is skipped;

- press the *ENT* key*;*

- the display shows menu of start line leveling *Menu Start L.*

If there is no previous change point the height difference between benchmarks will b displayed.

The following data can be displayed in level screen, see fig. 1.24.



Fig, 1.24. Data of the end of line leveling

Displayed data after the line leveling is completed:

- the height difference between the benchmarks;

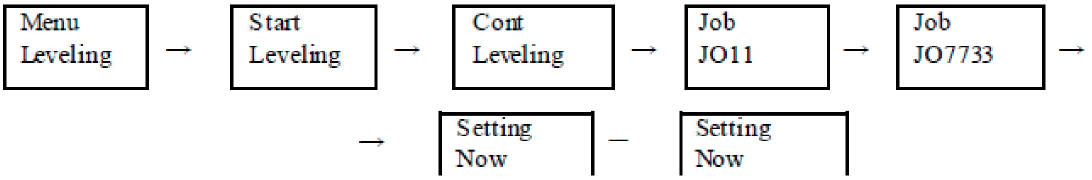
- horizontal distance from the last change point. If there is no previous change point, then this screen is not displayed;

- horizontal distance between the benchmarks;

- elevation of the benchmark.

Continuing leveling *Cont Leveling*

This mode is used to continue line-leveling job. Data must be stored to *Card* or *RAM.* The procedure of continuing leveling is provided in fig. 1.25.



Fig, 1.25. Procedure of continuing leveling

Measurement procedure:

1. Press the *ENT* key, if *Menu Leveling* is displayed*;*

2.To see the last displayed option press the [▲] key, *Cont Leveling* prompt will be displayed*;*

3. Press the *ENT* key. Job reference *Job JO11* is displayed.

4. Select a job by pressing the [▲] or [▼] key.

5. Press the *ENT* key.

6. *Setting Now* job data will be set.

7. Start measuring. You can exit the job only when the first backsight prompt is shown.

QUESTIONS TO REPEAT:

- What are the main components of the digital level *Topcon DL - 102 C*?
- How is the tripod of the instrument set up?
- How is the level set up over the point?
- How is the position of the digital level levelled?
- How is the level collated to the rod and how is the brightness adjusted?

- How is the data recording mode switch on/off?
- Summarize what parameters can you input in Set mode menu?
- What line leveling methods do you know?
- What are the main settings required to start the leveling?
- How are the measured data browsed through?
- What is difference between leveling patterns *Level 1, Level 2 and Level 3*?
- What are the main rules for point numbering?
- What is the procedure of point number change?
- What is the procedure of remeasurement?
- What is the procedure of intermediate point measurement?
- How is point set out performed?
- How is the intermediate point measurement stopped?
- How is the line leveling of the final benchmark completed?

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1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
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3	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
4	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.*	Издатель-ство	√		√

		ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	"Академи -ческий Проект"			
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2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
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2		http://www.topcon.lt				
3		http://www.gsb.lt				

* references for international students

Prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 2

TOPIC: MEASUREMENTS USING ELECTRONIC RANGE FINDER

1. The Aim of the Practical Work: to perform measurements using electronic range finders, to analyse measured data, to develop project of a building.

2. The Objectives of the Practical Work: to describe electronic range finders, to define building geometry using electronic range finders, to compute perimeter, area of the building and to develop a project of real estate - building.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
The outside of the building is measured using electronic range finder, building project at a scale of M 1 : 500 is developed applying *GeoMap* computer software, building area and perimeter are computed, precision of the measured line is evaluated.		The outside of the building is measured using electronic range finder, building project at a scale of M 1 : 500 is developed applying *GeoMap* computer software and has errors, building area and perimeter are computed, precision of the measured line is evaluated.		The outside of the building is measured using electronic range finder, building project at a scale of M 1 : 500 is developed applying *GeoMap* computer software and has errors, building area is computed, but perimeter is not computed, precision of the measured line is evaluated.		The outside of the building is measured using electronic range finder, building project at a scale of M 1 : 500 is developed applying *GeoMap* computer software and has errors, building area and perimeter are not computed, precision of the measured line is not evaluated.			

The teacher specifies the measurement object of the locality.

The measurements are performed by groups of two or three students.

Each group selects an electronic range finder from geodetic laboratory, prepares it for work using devise user manual and performs envisaged tasks.

Sequence of the practical work:

1. To measure the outside of the building using electronic range finder. The distance between building angles is provided in table 2.1..
2. To develop a building project at a scale of M 1 : 500 applying *GeoMap* computer software.
3. To compute building area and perimeter.
4. To evaluate the precision of measured distances in table 2.2..
5. To prepare presentation of practical work.

Table 2.1.

Distances between building angles

Building angles	**Measured distance, m**		
	I measurement	**II measurement**	**average**
1-2	19,052	19,053	19,05
2-3	3,341	3,342	3,34
3-4	2,960	2,960	2,96
4-5	3,744	3,742	3,74
5-6	2,941	2,943	2,94
6-7	6,772	6,773	6,77
7-8	1,682	1,684	1,68
8-9	3,401	3,400	3,40
9-10	1,271	1,271	1,27
10-11	2,722	2,724	2,72
11-12	2,981	2,981	2,98
12-13	3,273	3,272	3,27
13-14	6,571	6,572	6,57
14-15	4,752	4,751	4,75
15-16	8,590	8,591	8,59
16-17	4,971	4,972	4,97
17-18	2,712	2,712	2,71

18-19	3,154	3,152	3,15
19-20	1,732	1,731	1,73
20-21	3,241	3,241	3,24
21-22	3,031	3,031	3,03
22-23	14,610	14,611	14,61
23-24	3,612	3,611	3,61
24-1	2,021	2,020	2,02
Total			**113,10**

Building footprint – 607 m²

Table 2.2.

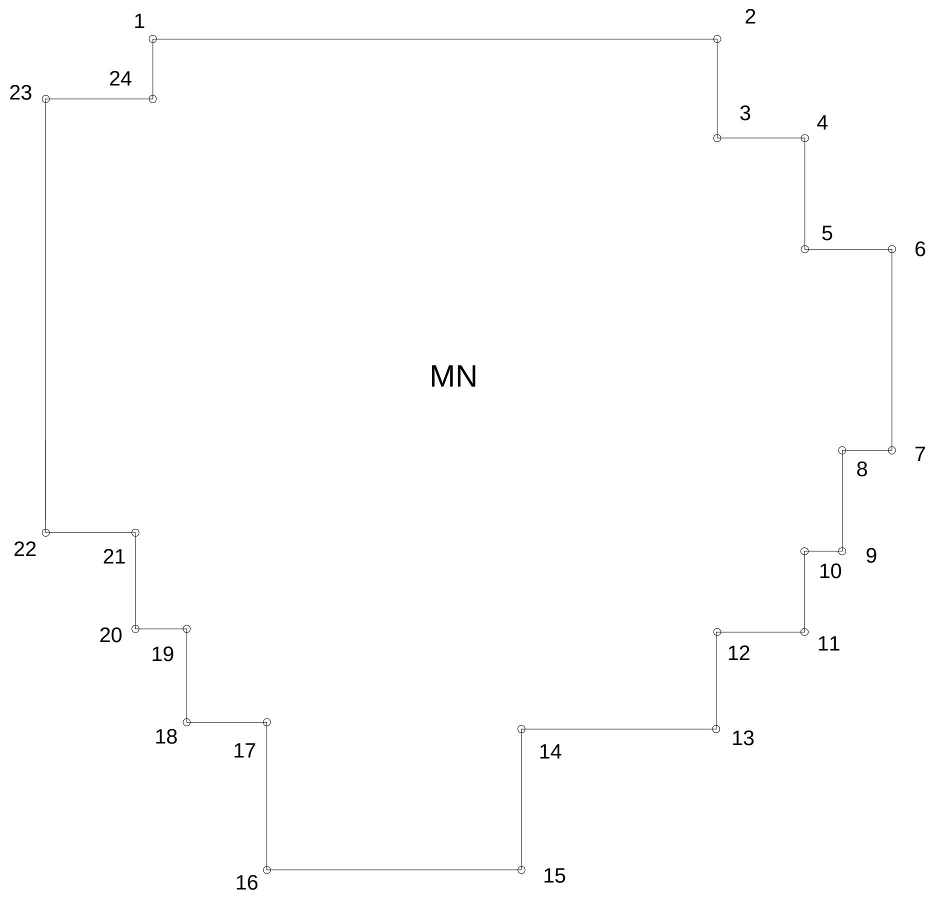
Distance measurement precision evaluation

Building angles	**Measured distance, m**		
	I measurement	**II measurement**	**Relative average deviation of measurement**
1-2	19,052	19,053	19100
2-3	3,341	3,342	3300
3-4	2,960	2,960	-
4-5	3,744	3,742	-
5-6	2,941	2,943	-
6-7	6,772	6,773	6800
7-8	1,682	1,684	-
8-9	3,401	3,400	3400
9-10	1,271	1,271	-
10-11	2,722	2,724	-
11-12	2,981	2,981	-
12-13	3,273	3,272	3300
13-14	6,571	6,572	6600
14-15	4,752	4,751	4800
15-16	8,590	8,591	8600
16-17	4,971	4,972	5000
17-18	2,712	2,712	-

18-19	3,154	3,152	-
19-20	1,732	1,731	-
20-21	3,241	3,241	-
21-22	3,031	3,031	-
22-23	14,610	14,611	14600
23-24	3,612	3,611	3600
24-1	2,021	2,020	2000
Maximum relative error of measurement			**2000**

BUILDING PROJECT

PASTATO PROJEKTAS
M 1 : 500



The project prepared by _______________group student

____

QUESTIONS TO REPEAT:

1. What distance measuring instruments do you know?
2. What is the procedure of distance measurement using optical theodolite?
3. It is allowed to measure lines by electronic tachometer up to ...
4. What is the main condition for measurement of a line?

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2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
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		ISBN 5-420-01331-2. 292 p.	dijų leidykla			
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5	2012	TORGE, WOLFGANG; MÜLLER, JÜRGEN. *Geodesy.* ISBN 978-3-11-020718-7. 539 p.*	University of Hannover, Germany.	√		√
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3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.infoera.lt				

* references for international students

Prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 3

TOPIC: MEASUREMENTS USING ELECTRONIC TACHOMETERS

1. The Aim of the Practical Work: to measure pickets using electronic tachometer, to prepare picket measurement report and the list of point coordinates in WGS 84 coordinate system datum.

2. The Objectives of the Practical Work: to describe the tachometers available at the geodetic laboratory, to designate fundamental differences between various types of tachometers, to get the instrument ready to measure, to coordinate the pickets using electronic tachometer, to print the report on picket measurement, to prepare the list of point coordinates according to the World Geodetic System WGS 84.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

The practical work is adapted for international students. Coordinated points are linked to the LKS 94 coordinate system. To use the data the geodetic and plane rectangular coordinates of points are converted to WGS 84 coordinate system. WGS 84 coordinate system is widely used all over the world.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
The tachometers available at the geodetic laboratory are described, fundamental differences between various types of tachometers are designated, the tripod with the instrument on the base point is set up, the instrument is aligned and levelled, the electronic tachometer is ON and ready to measure, pickets are coordinated, measurement report is provided, the list of point coordinates according to		The tachometers available at the geodetic laboratory are described, fundamental differences between various types of tachometers are designated, the tripod with the instrument on the base point is set up, the instrument is aligned and levelled, the electronic tachometer is ON and ready to measure, pickets are coordinated, measurement report is provided, the list of point coordinates according to		The tachometers available at the geodetic laboratory are described, fundamental differences between various types of tachometers are designated, the tripod with the instrument on the base point is set up, the instrument is aligned and levelled, the electronic tachometer is ON and ready to measure, pickets are coordinated, measurement report is not provided, the list of point		The tachometers available at the geodetic laboratory are described, fundamental differences between various types of tachometers are not designated, the tripod with the instrument on the base point is set up, the instrument is aligned and levelled, the electronic tachometer is ON and			

WGS 84 coordinate system is prepared.	WGS 84 coordinate system is not prepared.	coordinates according to WGS 84 coordinate system is not prepared.	ready to measure, pickets are not coordinated, measurement report is not provided, the list of point coordinates according to WGS 84 coordinate system is not prepared.

Sequence of the practical work:

1. To describe the tachometers available at the geodetic laboratory.
2. To designate fundamental differences between various types of tachometers.
3. To set up the instrument on the snapshot base point;
4. To align and level the instrument.
5. To get the instrument ready to measure the pickets (points).
6. To prepare the report on picket measurement (fig. 3.1.).
7. To prepare the list of point coordinates according to the general (world) WGS 84 coordinate system (table 3.1.).
8. To prepare presentation of practical work.

The teacher specifies the measurement object of the locality.

The measurements are performed by groups of three or four students.

Each group selects an electronic tachometer from geodetic laboratory, prepares it for work using devise user manual. Each student measures ten pickets.

When the task is completed, each group holds a presentation.

Getting the tachometer ready for work:

- tachometer is set up on snapshot base point, aligned and levelled;
- instrument is switched on;
- air temperature and atmosphere pressure are set. These data is necessary to calculate measure distance corrections;
- excitation of instrument horizontal limb and collimation eyepieces;
- new job is created.

Input of station parameters and measurements

Station parameters are input using tachometer user manual. The instrument will ask to input station title (ST), height of instrument (HI), title of backsight station (BS) and azimuth (AZ). If local coordinates are used, the AZ equals 0º00´00´´. The most of tachometers require setting the coordinates of station title (ST) and backsight station (BS), and then the azimuth (AZ) is automatically computed. A prism is installed on the point of backsight station (BS) and vertical collimation to it is performed. Verification is carried out according to the instructions provided is the user manual. Further, the pickets are measured.

During rotation of the horizontal limb the reading of horizontal angle (HA) is displayed. When eyepieces are rotated, the reading of vertical angle (VA) is displayed. Distance measuring key is pressed for distance measurement. The tachometers with integrated non-prismatic distance measurement may have two keys – for measurement with prism and laser waves.

Prism is set up to measure the picket. Vertical and horizontal collimation to prism centre is performed and distance measurement key is pressed. The height of tripod of the prism (HT), title and code of measured picket are entered and recorded by pressing *REC* or *ENT* key, depending on the type of tachometer. Measurement results are automatically recorded to data storage unit. After picket measurement is completed, readings of horizontal and vertical angle (HA,VA) are displayed, after tilting – vertical and horizontal distance (SD,VD,HD). Coordinates of measured pickets are displayed according to the coordinates of these stations. Other pickets are measured applying the same method.

Picket measurement report

CO.Nikon RAW data format V2.00
CO,12GDI01
CO,Description:
CO,Client:
CO,Comments:
CO,Downloaded 26-Aug-201116:49:27
CO,Software: Pre-install version: 1.10
CO,lnstrument: Nikon NPL-632
CO.Dist Units: Metres
CO.Angle Units: DDDMMSS
CO.Zero azimuth: North
CO,Zero VA: Zenith
CO,Coord Order: ENZ

CO,HA Raw data: HA zero to BS

CO.Tilt Correction: VA:ON HA:ON

CO, 12GDI01 <JOB> Created 12-Aug-201115:37:07

CO,S/N:020635

CO,Temp:18C Press:760mmHg Prism:0 12-Aug-201115:41:48

CO.HA set in Quick Station

ST,1,,,,1.7800,0.0000,0.0000

SS,2,1.8500,227.88,350.3335,89.5720,15:55:41,100

SS,3,1.8500,227.20,351.1824,89.5635,15:56:12,51

SS,4,1.8500,218.56,352.0100,89.5807,15:59:07,51

SS,5,1.8500,76.61,352.4657,89.3949,16:02:28,51

SS,6,1.8500,76.03,355.1604,89.3951,16:03:08,51

SS,7,1.8500,69.73,2.0803,89.2553,16:05:39,29

SS,8,1.8500,72.75,358.1622,89.3410,16:07:53,51

SS,9,1.8500,69.88,1.1150,89.2609,16:10:38,15

SS,10,1.8500,66.05,1.5424,89.2410,16:11:37,51

SS,11,1.8500,51.87,10.3018,89.2310,16:13:22,51

SS,12,1.8500,50.71,11.0202,89.1100,16:14:14,51

SS,13,1.8500,40.83,11.4142,89.0502,16:15:52,20

SS,14,1.8500,50.57,14.5540,89.1314,16:17:16,51

SS,15,1.8500,43.78,32.5331,89.0423,16:19:05,29

SS,16,1.8500,41.81,32.4939,89.0227,16:20:25,51

SS,17,1.8500,,31.4706,88.5938,16:21:21,51

SS,18,1.8500,40.11,31.4707,88.5938,16:21:28,51

SS,19,1.8500,34.90,34.2346,88.5705,16:22:23,22

SS,20,1.8500,37.95,43.0117,89.1957,16:26:57,51

SS,21,1.8500,57.72,39.4128,89.2113,16:29:10,29

SS,22,1.8500,51.94,42.0206,89.2330,16:30:13,51

SS,23,1.8500,57.70,43.2301,89.1757,16:31:50,51

SS,24,1.8500,59.08,42.5931,89.2417,16:33:02,51

SS,25,1.8500,60.08,41.4709,89.2510,16:33:34,51

SS,26,1.8500,66.71,52.0932,89.3125,16:35:00,51

SS,27,1.8500,58.86,S1.4656,89.2243,16:35:57,51

SS,28,1.8500,58.80,57.3724,89.1746,16:37:03,51

SS,29,1.8500,58.88,61.4329,89.1509,16:38:00,51

55,30,1.8500,53.77,62.1858,89.1203,16:38:28,51

SS,31,1.8500,55.74,56.3610,89.0920,16:43:57,20

SS,32,1.8500,,56.3610,89.0920,16:44:03,20

SS,33,1.8500,46.96,54.1256,89.0637,16:45:46,20

SS,34,1.8500,42.38,50.1608,89.1300,16:46:46,51

55,35,1.8500,46.97,63.0503,88.5420,16:47:56,51

SS,36,1.8500,26.13,57.4647,88.2543,16:50:00,15

SS,37,1.8500,24.87,50.3133,88.4802,16:51:07,15

SS,38,1.8500,24.92,56.0728,89.1015,16:52:18,15

SS,39,1.8500,22.23,56.2803,88.5846,16:53:19,15

SS,40,1.8500,22.24,49.5732,89.0239,16:54:12,15

Fig. 3.1. Picket measurement report

Table 3.1.

The list of point coordinates

WGS 84 coordinate system

Points	Geodetic coordinates, degrees	
	Φ	**λ**
1	54,23869450	24,91260150
2	54,23867313	24,91258700
3	54,23870091	24,91264759
4	54,23887009	24,91254254
5	54,23877590	24,91265365
6	54,23869137	24,91260281
7	54,23865537	24,91254314
8	54,23853220	24,91244876
9	54,23869108	24,91260308
10	54,23849211	24,91238376
11	54,23837699	24,91226615
12	54,23828214	24,91217106
13	54,23818933	24,91199488
14	54,23809671	24,91194949
15	54,23820782	24,91202828
16	54,23829300	24,91214727
17	54,23838486	24,91224251
18	54,23869161	24,91260389
19	54,23844960	24,91233536
20	54,23850515	24,91242798
21	54,23868578	24,91260346
22	54,23857274	24,91249984
23	54,23861757	24,91253671

24	54,23867575	24,91258937

ADDITIONAL MATERIAL FOR COMPLETION OF THE PRACTICAL WORK

It is recommended to ascribe special codes to the measured pickets during the operation with electronic tachometers. Coding system is necessary to see the conventional sign block when working with computer software. Some codes of the point conventional signs recognized by *GeoMap* software are provided in table 3.2.

Table 3.2.

***GeoMap* codes for some of the points**

No.	**Point title**	**Code**	**No.**	**Point title**	**Code**
1.	Movement point	1	21.	Storm runoff cover	371
2.	Reinf. concrete border column	2	22.	Heat chamber cover	40
3.	Wooden border column	3	23.	Gas pipeline cover	44
4.	Temporary border column	4	24.	Drainage well cover	45
5.	Electrical support (low voltage)	12	25.	Artesian well	46
6.	Electrical support (high voltage)	13	26	Communication support	49
7.	Street lamp	14	27.	Monuments	52
8.	Well	15	28.	Fountain	54
9.	Cover	16	29.	Semaphore	55
10.	Road sign	17	30.	Traffic light	56
11.	Broadleaf tree	1S	31.	Countdown marker	60
12.	Narrow-leaved tree	20	32.	Road sign	61
13.	Fir tree	21	33.	Bus station	62
14.	Pine tree	22	34	Religious signs	63
15.	Cedar	23	35.	Coupling	69
16.	Fruit tree	24	36.	Valve	70
17.	Single bush	25	37.	Grating	71
18.	Communication well	33	3S.	Signpost	72
19.	Water supply well	35	39.	Polygonal point	100
20.	Sewage cover	37	40.	Wall benchmark	103

QUESTIONS TO REPEAT:

- What are the main components of electronic tachometer?
- What characteristics are used to describe the precise electronic tachometers?

- What is measured by electronic tachometers?
- What is the procedure of preparation of the electronic tachometer for measurements?
- What readings are displayed after picket measurements?
- What is the aim of picket codes?

REFERENCES

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	*(a tick-mark shall mean availability of the source)*		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	HARRY, L. *Landscape Surveying.* ISBN 9781111310608. 256 p.*	Department of Agricultural Engineering, Oklahoma State University, USA	√		√
4	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
5	2011	Е., В., ЗОЛОТОВА; Р., Н., СКОГОРЕВА. *Геодезия с основами кадастра.* ISBN 978-5-904954-04-8, 978-5-8291-1246-2. 416 p.*	Академи-ческий Проект, Трикста	√		√
Additional Reading						
1	1998	SKEIVALAS, Jonas. *Elektroniniai geodeziniai prietaisai* ISBN 9986-05-713-2. 193 p.	Technika	√		√
2	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
3	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.* ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	Издатель-ство "Академи-ческий Проект"	√		√
4	2003	ERIK W. GRAFAREND, FRIEDRICH W. KRUMM, VOLKER S. SCHWARZE. *Geodesy – The Challenge of the 3rd Millennium.* ISBN-10: 3642077331. 487 p.*	Springer – Verlag Berlin Heidelberg	√		√
5	2000	Geodezijos ir kartografijos techninis	Valstybinė	√		√

		reglamentas. *GKTR 2.08.01:2000: statybiniai inžineriniai geodeziniai tyrinėjimai*	geodezijos ir kartografijos tarnyba			
Periodicals						
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.gpspartneris.lt				
4		http://www.infoera.lt				
5		http://www.geoportalas.lt				
6		http://www.gsb.lt				

* references for international students

Prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/University Of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 4

TOPIC: PLANNING IN *GEOMAP* SOFTWARE

1. The Aim of the Practical Work: to create topographic map, to prepare the lists of point coordinates according to LKS 94 and WGS 84 coordinate systems.

2. The Objectives of the Practical Work: to select an electronic tachometer from geodetic laboratory; to link *N* area to geodetic base points, to measure map points applying polar method, to perform calculations of coordinates using *GeoMap* software, to develop a project – topographic map using *GeoMap* software, to transform point coordinates from LKS 94 coordinate system to WGS 84 (eng. *World Geodetic System*, 1984) coordinate system, to prepare the lists of point coordinates according to LKS 94 and WGS 84 coordinate systems.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

The practical work is also applied for international students. Lithuanian and international students prepare the list of point coordinates of WGS 84 coordinate system.

4. Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
N area is linked to geodetic base points, pickets are measured applying polar method, coordinates are calculated, topographic map is created, report on picket (point) measurement and list of point coordinates of WGS 84 coordinate system are prepared.		*N* area is linked to geodetic base points, pickets are measured applying polar method, calculation of coordinates is wrong, topographic map is created, report on picket (point) measurement and list of point coordinates of WGS 84 coordinate system are prepared.		*N* area is linked to geodetic base points, pickets are measured applying polar method, calculation of coordinates is wrong, topographic map is not completely created, report on picket (point) measurement or list of point coordinates of WGS 84 coordinate system are not prepared.		*N* area is linked to geodetic base points, pickets are measured applying polar method, calculation of coordinates is wrong, topographic map is not created or only part of the map is created, report on picket (point) measurement and list of point coordinates of WGS 84 coordinate system are not prepared.			

The teacher specifies the measurement object of the locality.

The measurements are performed by groups of three or four students.

Each group selects a tachometer from geodetic laboratory, prepares it for work using devise user manual and performs survey of the territory. Each student measures ten pickets.

Each student individually create topographic map.

When the task is completed, each group holds a presentation on the practical work.

Sequence of the practical work:

1. To select electronic tachometer from geodetic laboratory.
2. To select and set out geodetic base points of *N* object of the locality.
3. To link the coordinates of geodetic base points to LKS 94 coordinate system.
4. To measure pickets applying polar method.
5. To create locality sketch plan in the course of measurement.
6. To import measurement data to computer – to new job.
7. To process the data with *GeoMap* software.
8. To create a M 1 : 500 scale topographic map - project using *GeoMap* software (fig. 4.1.).
9. To transform LKS 94 coordinates of pickets to WGS 84 coordinates.
10. To prepare report on picket (point) measurement (fig. 4.2.).
11. To create the list of picket (point) coordinates according to WGS 84 coordinate system (fig. 4.3.).
12. Created job is saved in computer data medium.
13. To prepare a presentation.

TOPOGRAPHIC MAP

M 1 : 500

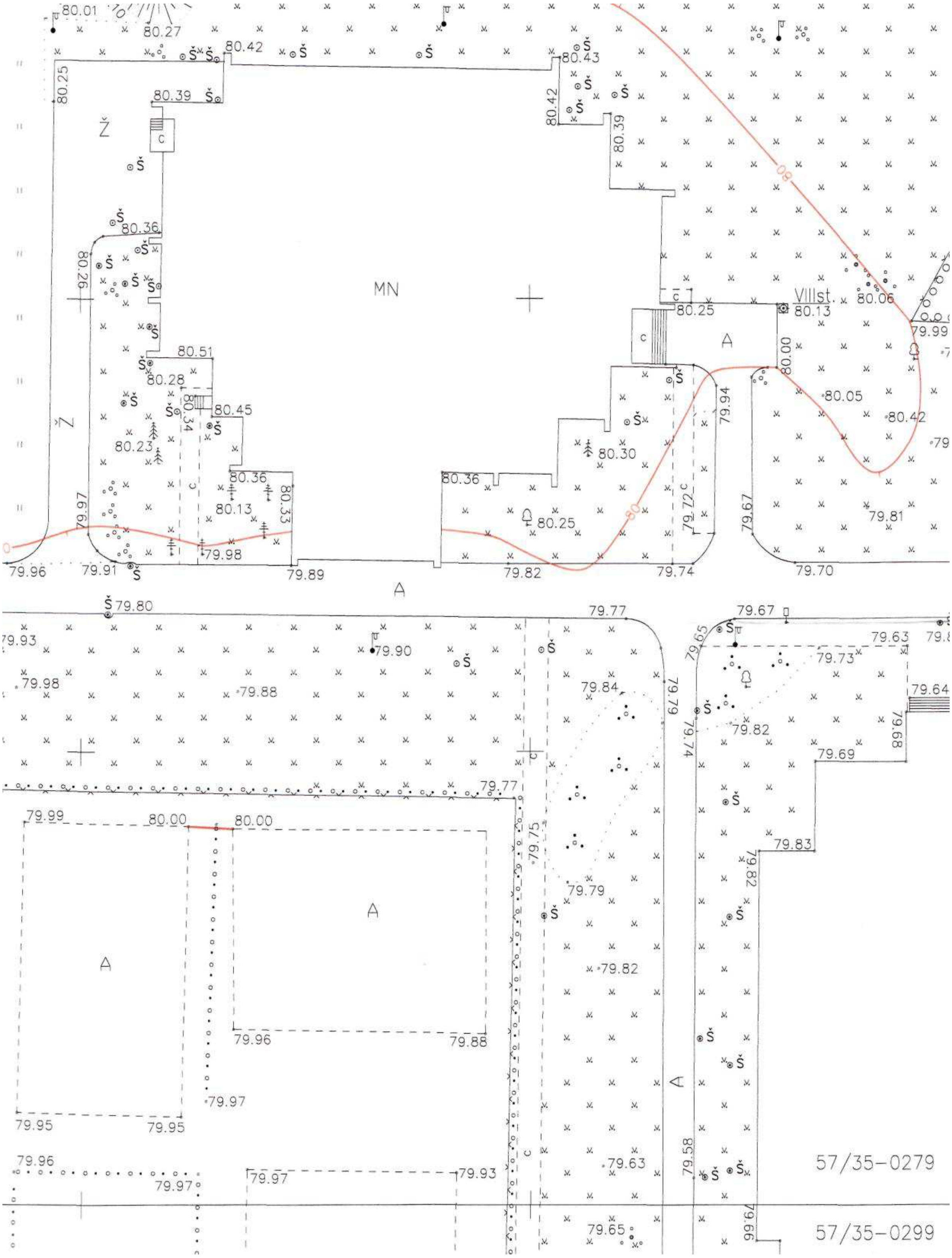


Fig. 4.1. Topographic map

REPORT ON PICKET (POINT) MEASUREMENT

```
CO,Nikon RAW data format V2.00
CO,12GDI01
CO,Description:
CO,Client:
CO,Comments:
CO,Downloaded 26-Aug-2011 16:49:27
CO,Software: Pre-install version: 1.10
CO,Instrument: Nikon NPL-632
CO,Dist Units: Metres
CO,Angle Units: DDDMMSS
CO,Zero azimuth: North
CO,Zero VA: Zenith
CO,Coord Order: ENZ
CO,HA Raw data: HA zero to BS
CO,Tilt Correction:  VA:ON HA:ON
CO, 12GDI01 <JOB> Created 12-Aug-2011 15:37:07
CO,S/N:020635
CO,Temp:18C Press:760mmHg Prism:0 12-Aug-2011 15:41:48
CO,HA set in Quick Station
ST,1,,,,1.7800,0.0000,0.0000
SS,2,1.8500,227.88,350.3335,89.5720,15:55:41,100
SS,3,1.8500,227.20,351.1824,89.5635,15:56:12,51
SS,4,1.8500,218.56,352.0100,89.5807,15:59:07,51
SS,5,1.8500,76.61,352.4657,89.3949,16:02:28,51
SS,6,1.8500,76.03,355.1604,89.3951,16:03:08,51
SS,7,1.8500,69.73,2.0803,89.2553,16:05:39,29
SS,8,1.8500,72.75,358.1622,89.3410,16:07:53,51
SS,9,1.8500,69.88,1.1150,89.2609,16:10:38,15
SS,10,1.8500,66.05,1.5424,89.2410,16:11:37,51
SS,11,1.8500,51.87,10.3018,89.2310,16:13:22,51
SS,12,1.8500,50.71,11.0202,89.1100,16:14:14,51
SS,13,1.8500,40.83,11.4142,89.0502,16:15:52,20
SS,14,1.8500,50.57,14.5540,89.1314,16:17:16,51
SS,15,1.8500,43.78,32.5331,89.0423,16:19:05,29
SS,16,1.8500,41.81,32.4939,89.0227,16:20:25,51
SS,17,1.8500,,31.4706,88.5938,16:21:21,51
SS,18,1.8500,40.11,31.4707,88.5938,16:21:28,51
SS,19,1.8500,34.90,34.2346,88.5705,16:22:23,22
SS,20,1.8500,37.95,43.0117,89.1957,16:26:57,51
SS,21,1.8500,57.72,39.4128,89.2113,16:29:10,29
SS,22,1.8500,51.94,42.0206,89.2330,16:30:13,51
SS,23,1.8500,57.70,43.2301,89.1757,16:31:50,51
SS,24,1.8500,59.08,42.5931,89.2417,16:33:02,51
SS,25,1.8500,60.08,41.4709,89.2510,16:33:34,51
SS,26,1.8500,66.71,52.0932,89.3125,16:35:00,51
SS,27,1.8500,58.86,51.4656,89.2243,16:35:57,51
SS,28,1.8500,58.80,57.3724,89.1746,16:37:03,51
SS,29,1.8500,58.88,61.4329,89.1509,16:38:00,51
SS,30,1.8500,53.77,62.1858,89.1203,16:38:28,51
SS,31,1.8500,55.74,56.3610,89.0920,16:43:57,20
SS,32,1.8500,,56.3610,89.0920,16:44:03,20
SS,33,1.8500,46.96,54.1256,89.0637,16:45:46,20
SS,34,1.8500,42.38,50.1608,89.1300,16:46:46,51
SS,35,1.8500,46.97,63.0503,88.5420,16:47:56,51
SS,36,1.8500,26.13,57.4647,88.2543,16:50:00,15
SS,37,1.8500,24.87,50.3133,88.4802,16:51:07,15
SS,38,1.8500,24.92,56.0728,89.1015,16:52:18,15
SS,39,1.8500,22.23,56.2803,88.5846,16:53:19,15
SS,40,1.8500,22.24,49.5732,89.0239,16:54:12,15
SS,41,1.8500,10.88,6.1602,87.5600,17:02:31,51
SS,42,1.8500,13.45,17.3326,88.1620,17:03:26,51
SS,43,1.8500,23.79,13.5426,88.5207,17:05:18,21
SS,44,1.8500,,353.0259,89.0826,17:08:14,51
SS,45,1.8500,12.58,344.1158,88.3001,17:10:45,51
SS,46,1.8500,34.24,356.5709,89.1537,17:12:37,15
SS,47,1.8500,35.21,353.0034,89.2204,17:13:17,15
SS,48,1.8500,38.88,348.5231,89.1822,17:15:02,12
SS,49,1.8500,43.20,349.1258,89.1843,17:21:16,12
SS,50,1.8500,70.57,353.3616,89.3815,17:22:51,15
SS,51,1.8500,78.88,352.1652,89.3757,17:25:06,12
```

Fig. 4.2. Report on picket (point) measurement

LIST OF PICKET (POINT) COORDINATES

WGS 84 COORDINATE SYSTEM

Points	Geodetic coordinates, degrees		Planar rectangular coordinates, m	
	Φ	**Λ**	***X***	***Y***
1	54,23869450	24,91260150	3388217,927	1573664,253
2	54,23867313	24,91258700	3388220,076	1573664,208
3	54,23870091	24,91264759	3388216,136	1573666,734
4	54,23887009	24,91254254	3388205,161	1573654,085
5	54,23877590	24,91265365	3388209,826	1573664,239
6	54,23869137	24,91260281	3388218,147	1573664,449
7	54,23865537	24,91254314	3388222,735	1573662,291
8	54,23853220	24,91244876	3388235,417	1573661,395
9	54,23869108	24,91260308	3388218,163	1573664,476
10	54,23849211	24,91238376	3388240,487	1573659,077
11	54,23837699	24,91226615	3388253,148	1573656,502
12	54,23828214	24,91217106	3388263,531	1573654,488
13	54,23818933	24,91199488	3388275,973	1573647,601
14	54,23809671	24,91194949	3388284,806	1573648,440
15	54,23820782	24,91202828	3388273,540	1573648,872
16	54,23829300	24,91214727	3388263,294	1573652,668
17	54,23838486	24,91224251	3388253,153	1573654,805
18	54,23869161	24,91260389	3388218,098	1573664,504
19	54,23844960	24,91233536	3388245,299	1573657,832
20	54,23850515	24,91242798	3388238,204	1573661,196
21	54,23868578	24,91260346	3388218,588	1573664,700
22	54,23857274	24,91249984	3388230,694	1573662,873
23	54,23861757	24,91253671	3388226,008	1573663,348
24	54,23867575	24,91258937	3388219,796	1573664,249

Fig. 4.3. List of picket (point) coordinates, WGS 84 coordinate system

ADDITIONAL MATERIAL FOR COMPLETION OF THE PRACTICAL WORK

GeoMap is *InfoEra* product compatible with *Autodesk* Inc. Created on *AutoDesk Map*. This program enables efficient management of field measurement data.

Scale

Drawing scale and conversion commands are triggered by clicking menu *Geo* → *Scale* or from toolbar *Mastelis (Scale)*:

– keys are used to change drawing scale to 1:100, 1:200, 1:500, 1:1000, 1:2000, 1:5000, 1:10000.

– key is used to change drawing scale by typing in the scale at the command prompt.

– key for scale conversion. The command changes the *scale* of blocks and text and *global weight* of line if it is not equal to 0. The properties of dynamic blocks also change. Scale conversion is performed even if existing scale coincide with the converted one. If the scale is changed to 500, then *scale* parameter of a block is set to 0,5, if 1000 – to 1 and etc.. When triggering the command, it is necessary to specify the **blocks** to be converted – *visus* (*all)* or only *prasidedančius skaičiumi (started from number)*, and select new scale.

– key used for drawing review on A3 or A4 paper format. If the drawing does not fit A3 or A4 paper, it can be reduced, enlarged, or drawing centre can be changed. Open command menu and proceed with the following steps:

- Select the format – A3 or A4.
- Specify centre of site plan.
- Reduce or enlarge the scale (100, 200, 500, 1000, 2000, 5000, 10000). Adjust the centre if necessary. If you want to finish customizing the scale press *Baigti (Finish)*.
- To convert the same scale to the drawing select *Taip (Yes)* or opposite *Ne (No)*.
- After selection of conversion of objects the programme will ask what objects are to be converted – all or started from number.
- Then to save current drawing select *Taip (Yes)* or *Ne (No)*.

When these steps are completed, the programme sets up the scale and converts objects, if conversion of blocks is also selected.

Import of points

Import of pickets from text file is performed through command menu. The command is triggered in several ways:

- by clicking menu command *Geo → Taškų importas (Geo → Point import);*
- by pressing key on *Geo* toolbar;
- by typing in command GEOMAP_TASKU_IMPORTAS at the command prompt.

After command triggering a box appears with text file with information about the pickets. After required file is selected *Open* key is pressed. After these steps the pickets will be imported to the drawing.

Symbols

Use *Geo* → *Ženklai* (*Geo* → *Symbols)* menu or Toolbar *Ženklai (Symbols)* to select symbols and insert functions:

Meanings of Toolbar icons:

 – taškinių ženklų dėjimas su ženklo pasirinkimo dialogu/dot symbols with symbol selection dialog;

 – taškinių ženklų dėjimas be ženklo pasirinkimo dialogo/dot symbols without symbol selection dialog;

 – linijinių ženklų dėjimas su ženklo pasirinkimo dialogu/line symbols with symbol selection dialog;

 – linijinis ženklas per taškų numerius/line symbol by point numbers;

 – linijinių ženklų dėjimas be ženklo pasirinkimo dialogo/line symbols without symbol selection dialog;

 – vartotojo pasirinkto sutartinio linijinio ženklo dėjimas/user-selected line symbol;

 – plotinių ženklų dėjimas su ženklo pasirinkimo dialogu/area symbols with symbol selection dialog;

 – plotinių ženklų dėjimas be ženklo pasirinkimo dialogo/area symbols without symbol selection dialog;

 – šlaito braižymas/draw the slope;

 – sklypo ribos braižymas/site boundary drawing;

 – naudmenų ribos braižymas/land boundary drawing;

 – vienodo kodo piketų apjungimas/linking of same code pickets.

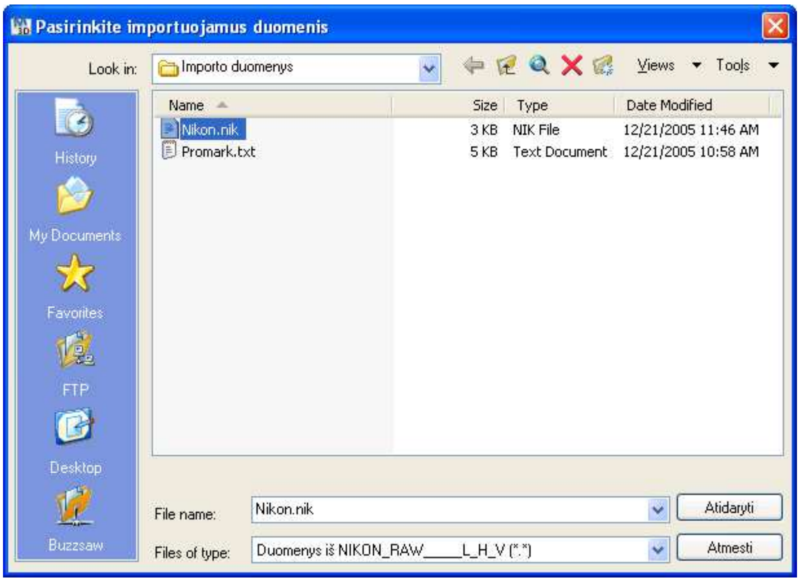
Note. The *Ženklai (Symbols*) toolbar of *GeoMap* previous version included commands: „*Juostinių ženklų dėjimas su ženklo pasirinkimo dialogu*“/„*Strip symbols with symbol selection dialog*“ and „*Juostinių ženklų dėjimas be ženklo pasirinkimo dialogo*“/„*Strip symbols without symbol selection dialog*“. In 2008 version these command are revealed. They should be removed in the future because of presence of line symbols placement command. It is still possible to trigger „*Juostinių ženklų dėjimas su ženklo pasirinkimo dialogu*“/„*Strip symbols with symbol selection dialog*“ and „*Juostinių ženklų dėjimas be ženklo pasirinkimo dialogo*“/„*Strip symbols without symbol selection dialog*“ commands in the command line by entering appropriate name. Read about these commands in section „*Juostinių ženklų braižymas*“/„*Strip Symbol Drawing*“.

More:

Taškinių ženklų dėjimas	Dot symbols
Linijinių ženklų dėjimas	Line symbols
Linijinis ženklas per taškų numerius	Line symbol by point numbers
Apsaugos vamzdžio braižymas	Protective pipe drawing
Plotinių ženklų dėjimas	Area symbols
Juostinių ženklų braižymas	Strip symbol drawing
Šlaito braižymas	Slope drawing
Dažniausiai naudojamas šlaitas	Predominant slope
Sklypo ribos braižymas	Site boundary tracing
Naudmenų ribos braižymas	Agricultural land boundary drawing
Vienodo kodo piketų apjungimas	Connection of same code pickets

Import

In dialog box *Matavimų duomenys (Measurement data)* key *Importuoti (Import)*  or menu *Veiksmai → Importuoti* (*Actions → Import)* are used for data import from electronic tachometers. Call the command and see a dialog box where select the file from which the data must be imported. Also select required measurement device:



The data is imported to traverse levelling dialog. Format file structure is described in section *Formatų failo struktūra (Format file structure).*

Traverse management

The command is invoked by pressing key.

It is used during the import of measured data from devices without indicating fixed points. As the command for data import of traverse adjustment activates an automatic marking of traverse with input of data, lack of information about fixed points will lead to unmarked traverse. Thus, fixed points must additionally be uploaded or entered, and the command „*Sužymėti ėjimą*“ (*Mark traverse*) must be invoked to automatically stake out traverse points. This function is also used in any other cases when it was detected that the marking did not resume after certain actions.

Matavimų žurnalas

Nr.	Stotis	Kryptis	H °	'	"	V °	'		Atstumas	Kodas	Kodas prietaise	Papildoma informacija
1	4596	BAZN	0	0	0	89	5	2	0.200	Valstybinio geodezinio tinklo punktas		
2	4596	R	73	23	38	89	46	14	1311.760	Ėjimo taškas		
3	R	4596	0	0	0	90	14	54	1311.770	Valstybinio geodezinio tinklo punktas		
4	R	1	14	15	32	90	37	16	333.220	Pavieniai medžiai - siauralapiai		
5	R	R1	268	41	14	89	56	8	807.280	Ėjimo taškas		
6	R	2	309	21	40	90	11	36	878.580	Pavieniai medžiai - plačialapiai		
7	R	RUS	310	1	22	90	15	16	894.030	Pavieniai medžiai - plačialapiai		
8	R1	R	0	0	0	90	1	44	807.230	Ėjimo taškas		
9	R1	R2	182	13	32	90	6	24	1490.240	Ėjimo taškas		
10	R2	R1	359	59	58	89	54	58	1490.280	Ėjimo taškas		
11	R2	R3	178	54	42	89	33	56	1183.200	Ėjimo taškas		
12	R2	4	183	14	48	89	41	42	763.190	Pavieniai medžiai - plačialapiai		
13	R2	5	247	37	52	89	54	2	303.890	Kelio rodyklės		
14	R2	6	262	8	38	90	11	12	38.990	Pavieniai medžiai - plačialapiai		
15	R2	7	62	58	50	90	37	0	255.020	Spygliuota tvora		
16	R2	8	61	14	38	90	40	14	257.900	Pavieniai medžiai - plačialapiai		

Unmarked traverse in the surveying log

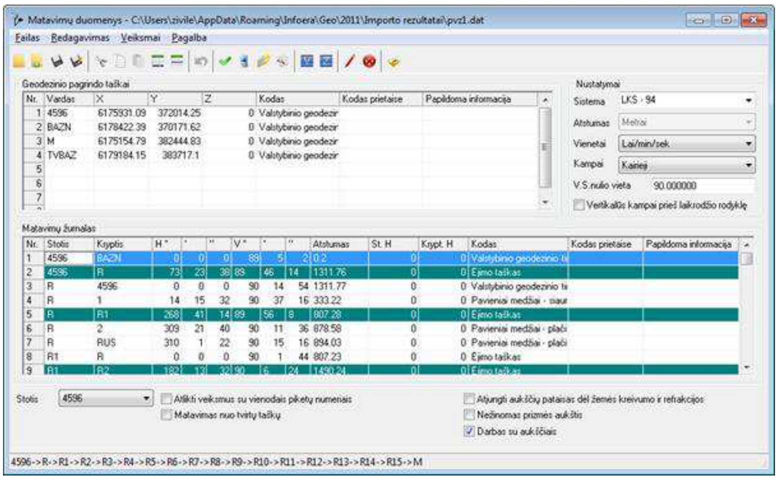
Matavimų žurnalas

Nr.	Stotis	Kryptis	H°	'	"	V°	'	"	Atstumas	Kodas	Kodas prietaise	Papildoma informacija
1	4596	BAZN	0	0	0	89	5	2	0.200	Valstybinio geodezinio tinklo punktas		
2	4596	R	73	23	38	89	46	14	1311.760	Ėjimo taškas		
3	R	4596	0	0	0	90	14	54	1311.770	Valstybinio geodezinio tinklo punktas		
4	R	1	14	15	32	90	37	16	333.220	Pavieniai medžiai - siauralapiai		
5	R	R1	268	41	14	89	56	8	807.280	Ėjimo taškas		
6	R	2	309	21	40	90	11	36	878.580	Pavieniai medžiai - plačialapiai		
7	R	RUS	310	1	22	90	15	16	894.030	Pavieniai medžiai - plačialapiai		
8	R1	R	0	0	0	90	1	44	807.230	Ėjimo taškas		
9	R1	R2	182	13	32	90	6	24	1490.240	Ėjimo taškas		
10	R2	R1	359	59	58	89	54	58	1490.280	Ėjimo taškas		
11	R2	R3	178	54	42	89	33	56	1183.200	Ėjimo taškas		
12	R2	4	183	14	48	89	41	42	763.190	Pavieniai medžiai - plačialapiai		
13	R2	5	247	37	52	89	54	2	303.890	Kelio rodyklės		
14	R2	6	262	8	38	90	11	12	38.990	Pavieniai medžiai - plačialapiai		
15	R2	7	62	58	50	90	37	0	255.020	Spygliuota tvora		
16	R2	8	61	14	38	90	40	14	257.900	Pavieniai medžiai - plačialapiai		

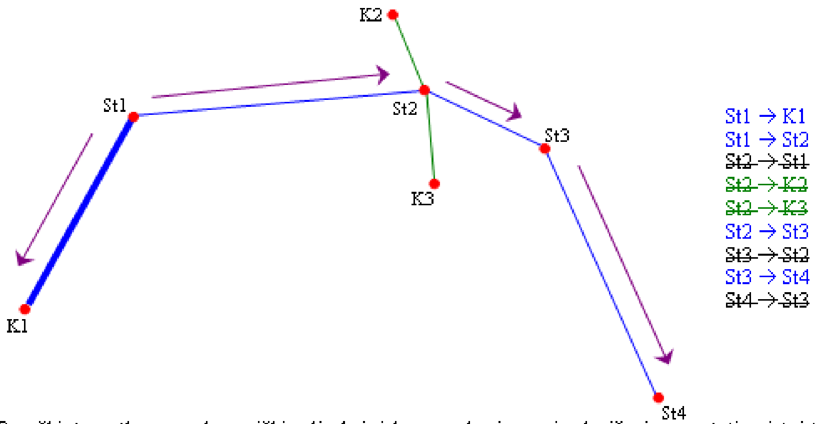
Marked traverse in the surveying log

Selecting planimetric traverse

Planimetric traverse points are marked by double left click on a mouse on the number of selected row in "Matavimų žurnalas"(*Surveying log*) of "Matavimų duomenys" (*Surveying data*) dialog box (see the fig. below):



First of all, select the surveying from the first station to a fixed point; direction angle is indicated by the surveying. Further, stake out remaining traverse points so that the second stations would be observed from the selected one (see the fig. below):

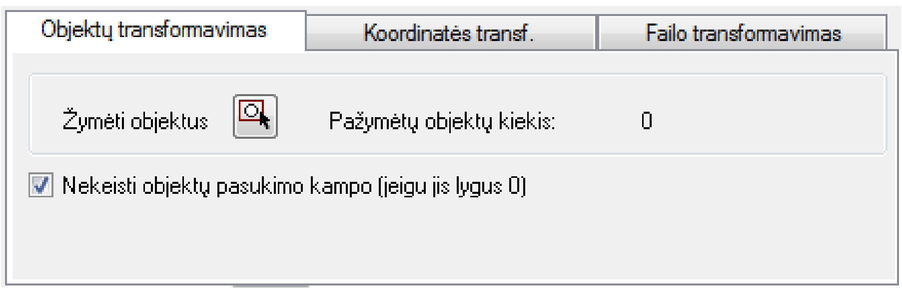


Paryškinta mėlyna spalva reiškia direkcinį kampą, kuris nusirodo iš pirmos stoties į tvirtą tašką. Mėlyna spalva nurodo ėjimą. Juoda spalva nurodo ėjimo stočių užnulinimą. Žalia spalva nurodo matuojamus taškus. Rodyklės rodo ėjimo kryptį.

Bold blue line stands for direction angle from the first station to the fixed point. Blue colour stands for traverse. Black colour stands for neutralling of traverse stations. Surveyed points are marked with green colour. Traverse direction is indicated by arrows.

Transformation of objects

To transform the objects from a drawing select *Objektų transformavimas (Transform objects)* tab:

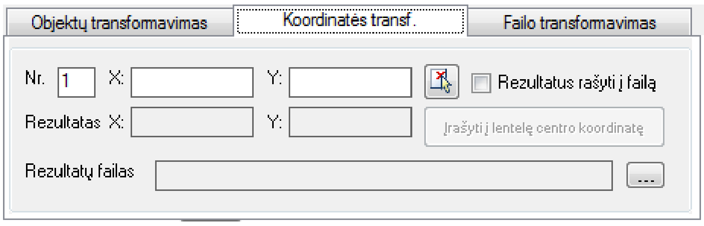


Here press the *Žymėti objektus*  *(Select objects)* key. Indicate the area of objects to be transformed between coordinate systems or select the objects one by one on the drawing. Then press ENTER button on the keyboard or make a right click on a mouse. After these steps you will see the objects selected for transformation.

Nekeisti objektų pasukimo kampo (jeigu jis lygus 0) (Do not change deflection angle of the objects (if it is 0) function may be selected to leave the objects undeflected.

Transformation of coordinates

To transform the coordinates of one point between coordinate systems select *Koordinatės transformavimas (transform coordinate)* tab:



Enter the coordinate of point X to *X* field of the dialog box, and Y coordinate - to *Y* field. The point may also be indicated on a drawing using a mouse by pressing  key.

To save transformed coordinates to result file tick *Rezultatus rašyti į failą* (*Record results to the file*) and press  located next to *Rezultatų failas (Result file)* line, indicate the file. Find the structure of the file in section *Rezultatų failo struktūra* (*Result file structure*).

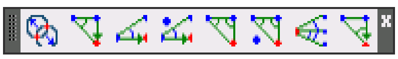
If the result is recorded to the file, indicate the number of transformed point in *Nr. (No.)* field. Result file may contain more than one record, therefore the points should be numbered.

When the results are obtained, centre coordinate may be entered to the table (the table is invoked by entering GEOMAP_LENTPILDYMAS_UZKRAUTI to command prompt). *Note:* it is possible to enter centre coordinate in GeoMap software only. The accuracy of coordinates is taken from GeoMap settings. In case the set accuracy is higher of that in Transformation dialog box, use the latter.

Note. Geographical coordinates must be expressed in degrees prior to transformation, i.e. to translate minutes and seconds to degree measure. E.g.: coordinate 30o 30’ is translated to 30,50; coordinate 30o07.30’ (30o07’30”) is translated to 30,125. X coordinate refers to eastern longitude, Y coordinate – to northern latitude.

Intersections (triangulation)

The intersections are found in menu option *Geo* → *Užkirčiai* (*Geo* → *Intersections*) or toolbar *Užkirčiai (Intersections)*:



Meanings of icons:

 – linijinis užkirtis / line intersection;

 – kampinis-linijinis užkirtis / angular-line intersection;

 – polinis užkirtis / polar intersection;

 – polinis užkirtis nuo bet kurio taško / polar intersection from any of the points;

 – kampinis užkirtis / angular intersection;

 – kampinis užkirtis nuo bet kurio taško / angular intersection from any of the points;

 – potenoto užkirtis / inverse geodetic intersection.

 – pririšimas prie žinomo taško užkirtis / known point dimensioning intersection.

More:

- Linijinis užkirtis;
- Kampinis-linijinis užkirtis;
- Polinis užkirtis;
- Polinis užkirtis nuo bet kurio taško;
- Kampinis užkirtis;
- Kampinis užkirtis nuo bet kurio taško;
- Potenoto užkirtis;
- Pririšimas prie žinomo taško užkirtis.

- line intersection;
- angular-line intersection;
- polar intersection;
- polar intersection from any of the points;
- angular intersection;
- angular intersection from any of the points;
- inverse geodetic intersection;
- known point dimensioning intersection.

Comments

To trigger commands for comments and annotations use menu option *Geo* → *Užrašai* (*Geo* → *Comments*) or toolbar *Užrašai (Comments)*. The *Užrašai (Comments)* toolbar is as follows:

Meaning of toolbar icons:

 – paprasto teksto rašymas / common text input;

 – užrašų iškėlimas ant kitų objektų / placement of comments on other objects;

– užrašo anotacija / annotation to comment;

– figūros ploto užrašymas / enter figure area;

– figūros ploto su tikslumu užrašymas / enter figure area with accuracy;

– srities ploto užrašymas / enter region area;

– srities ploto su tikslumu užrašymas / enter region area with accuracy;

– ploto anotacija / annotation to area;

– koordinačių užrašymas / enter coordinates;

– koordinačių užrašas su išnaša / enter coordinates with a note;

– koordinatės anotacija / annotation to coordinate;

– linijų atstumų užrašas / line distance comment;

– linijų anotacijos / annotations to lines;

– linijų anotacijos su lentele / annotations to lines with table;

– kampo užrašas / angle comment;

– piketo numerio užrašas / picket number;

– koordinačių tinklelio sudėjimas / making coordinate grid;

– koordinačių tinklelio sudėjimas nurodytoje srityje (taškais) / making coordinate grid on specified area (points);

– koordinačių tinklelio sudėjimas nurodytoje srityje (linijomis) / making coordinate grid on specified area (lines);

– koordinačių tinklelio anotacija / annotation to coordinate grid;

– teksto modifikavimas / modifying the text;

– teksto storinimas / bold text;

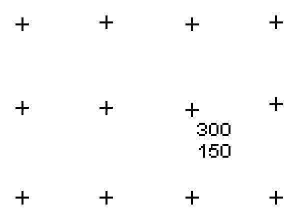
More:

- Paprasto teksto rašymas / common text input;
- Užrašų iškėlimas ant kitų objektų / placement of comments on other objects;
- Užrašo anotacija / annotation to comment;
- Figūros ploto užrašymas / enter figure area;
- Figūros ploto su tikslumu užrašymas / enter figure area with accuracy;

- Srities ploto užrašymas / enter region area;
- Srities ploto su tikslumu užrašymas / enter region area with accuracy;
- Ploto anotacija / annotation to area;
- Koordinačių užrašymas / enter coordinates;
- Koordinačių užrašas su išnaša / enter coordinates with a note;
- Koordinatės anotacija / annotation to coordinate;
- Linijų atstumų užrašas / line distance comment;
- Linijų anotacijos / annotations to lines;
- Linijų anotacijos su lentele / annotations to lines with table;
- Kampo užrašas / angle comment;
- Piketo numerio užrašas / picket number;
- Koordinačių tinklelio sudėjimas / making coordinate grid;
- Koordinačių tinklelio sudėjimas nurodytoje srityje (taškais) / making coordinate grid on specified area (points);
- Koordinačių tinklelio sudėjimas nurodytoje srityje (linijomis) / making coordinate grid on specified area (lines);
- Koordinačių tinklelio anotacija / annotation to coordinate grid;
- Teksto modifikavimas / modifying text;
- Teksto storinimas / bold text.

Making coordinate grid

The command helps to make a coordinate grid with indication of coordinates if required.



The command is invoked in several ways:

- through menu *Geo → Užrašai → Koordinačių tinklelis (Geo → Comments → Coordinate grid)*;
- from the toolbar *Užrašai (Comments)* by pressing ;

- by entering GEOMAP_UZRASAI_TINKLAS to command prompt.

The following steps:

1. Use left button of a mouse to indicate required network points (to call coordinate grid annotation settings press „*X*“).
2. Use right button of a mouse to end network set out.
3. If network coordinates are required press ENTER, or press *Ne (no)* to quit the command.
4. If ENTER is pressed, use left button of a mouse to indicate network point that needs coordinates to be specified.
5. Use left button of a mouse to indicate the deflection angle of X coordinate comment and place the comment to required location.
6. Enter Y coordinate according to step 5.
7. If other coordinates of the map are required, repeat activities from step 4.
8. To quit the command press ENTER.

A symbol for coordinate grid is taken from *koordinačių tinklelio nustatymuose (coordinate grid settings)*.

Coordinate grid annotation

The command is used to make coordinates of angles of coordinate grid.

The command is invoked in several ways:

- through menu *Geo → Užrašai → Koordinačių tinklelio anotacija (Geo → Comments → Coordinate grid annotation)*;
- from the toolbar *Užrašai (Comments)* by pressing ;
- by entering GEOMAP_KOORDTINKLELIS to command prompt.

The following steps:

1. To make comments automatically [Taip/Ne/nUstatymai] *([Yes/No/Settings])*. <Taip> *(<Yes>)*: - the comments will be automatically made. Otherwise:

a. Specify deflection angle of X comment

b. Move X comment to required location

c. Specify deflection angle of Y comment

d. Move Y comment to required location.

To open settings for coordinate grid annotation, press „*U*".

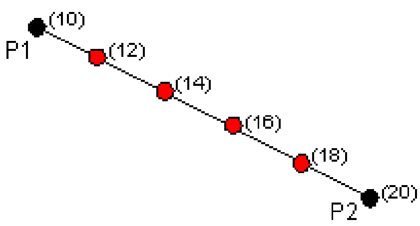
2. Indicate points <ENTER-pabaiga> (<ENTER-end>): - indicate points using a mouse to place annotations to these points.

3. To quit the command press ENTER.

The symbol for coordinate grid is taken from *koordinačių tinklelio nustatymuose (coordinate grid settings)*.

Interpolation

The command is used to calculate the height between two points. The heights of pickets P1 and P2 are known. Heights between these pickets are calculated according to the level of shown horizontal lines.



The command is invoked in several ways:

- through menu *Geo → Aukščiai → Interpoliavimas (Geo → Heights → Interpolation)*;
- from the toolbar *Informacija (Information)* by pressing ;
- by entering GEOMAP_AUKSCIAI_INTERPOLIAVIMAS to command prompt.

The following steps:

1. Use keyboard to enter the level of horizontal lines and press ENTER (press „*X*" to open the settings). Level of horizontal lines is a difference between heights determining the interval of setting out height points in meters.

2. Use keyboard to enter the minimum height and press ENTER. Minimum height is a reference height to start calculating other heights.

3. Indicate the first picket P1. If well indicated, press ENTER, otherwise press *Ne (No)* and reindicate the picket.

4. Similarly to step 3, indicate the second picket P2.

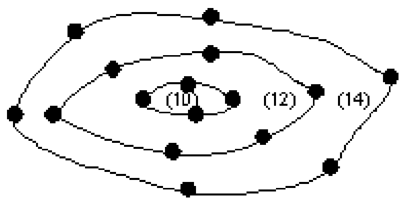
5. Select *Taip (Yes)* to question *Ar koreguosite taškų aukščių reikšmes?(Would you like to adjust point height?)* to change the altitudes of pickets P1 and P2. By pressing *Ne (No)*, the altitudes of pickets P1 and P2 are left unchanged.

6. Then calculate the heights.

7. Repeat the command from the 3rd step. To quit the command press ENTER.

Drawing horizontal lines

The command is used to draw horizontal lines. The height of each horizontal line is indicated in brackets in the figure below (linked points are of the same height).



The command is invoked in several ways:

- through menu *Geo → Aukščiai → Horizontalių braižymas (Geo → Heights → Drawing horizontal lines)*;
- from the toolbar *Informacija (Information)* by pressing ;
- by entering GEOMAP_AUKSCIAI_HORIZONTALES to command prompt.

The following steps:

1. Use keyboard to enter the height of horizontal line and press ENTER (press „*X*" to open the settings).

2. Markers indicating all pickets of the height appear.

3. Link required pickets. The function of linkage is analogous to the boundary linkage, but the line must be levelled after the linkage is completed.

4. Repeat the command from the 1st step. To quit the command press ENTER.

Comment annotation

The command is used to leave a comment on the drawing. The comment is made according to the *Geo* settings *užrašo anotacijos nustatymus* (*comment annotation settings*). Text style, layer, size, deflection angle, graphical code and use/do not use footnote parameters are set. The command is invoked in several ways:

- through menu *Geo* → *Užrašai* → *Užrašo anotacija (Geo* → *Comments* → *Comment annotation)*;
- from the toolbar *Užrašai (Comments)* by pressing ;
- by entering GEOMAP_UZRASUANOTACIJOS to command prompt.

The following steps:

1. Indicate the type of text binding in the command line. Binding type may include *vidurys (middle)*, *centras (centre)*, *dešinys (right)*, *kairys (left)* and *įtalpint (fit)*. For the meaning of each type refer to section *Paprasto teksto rašymas* (*Common text input*). Press „*X*“ to open comments settings.
2. Use the keyboard to enter standard comment and press ENTER.
3. Use the mouse to indicate the location of the comment on a drawing.
4. If the comment with a note is set, indicate the location of annotation.
5. Repeat the command from the 2nd step. To quit the command select *Pabaiga (End)* and press ENTER.

Line distance comment

The command is used to specify the distance between two indicated points. Distance comment is turned according to the line or indicated angle. Deflection type is specified in *linijos anotacijos nustatymuose (line annotation settings)*. The annotation is also rounded to the accuracy specified in *linijos anotacijos nustatymuose (line annotation settings)*.

The command is invoked in several ways:

- through the menu *Geo* → *Užrašai* → *Linijų atstumai (Geo* → *Comments* → *Line distance)*;
- from the toolbar *Užrašai (Comments)* by pressing ;
- by entering GEOMAP_UZRASAI_ATSTUMAI to command prompt.

The following steps:

1. Indicate the reference point. If the picket is indicated, press ENTER, otherwise press *Ne (No)* and repeat picket indication procedure.

2. Similarly to step 1, indicate the second reference picket.

3. Line length is entered. To confirm press ENTER or enter required line length and press ENTER. Press „*X*“ to open line annotation settings.

4. Use the left button of a mouse to appropriately locate the comment.

5. Repeat the command from the 1st step. To quit the command press ENTER.

Modifying the text

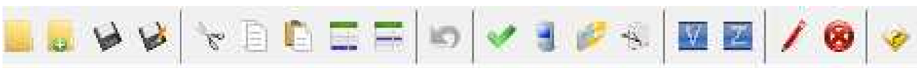
The command opens text editor and allows for editing the selected text. The command is invoked in several ways:

- through the menu *Geo → Užrašai → Tekstas → Modifikavimas (Geo → Comments → Text → Modify)*;
- from the toolbar *Užrašai (Comments)* by pressing ;
- by entering DDEDIT to command prompt.

Text object to be corrected must be selected after the command was triggered by mouse. Text editor opens after selection of text. Edit the text and press *OK*.

Traverse adjustment commands

Traverse adjustment toolbar:



The same commands are invoked both from the toolbar and menu. Fast one click invoking is available from the toolbar.

	*užkrauti duomenis/import data*	Command is used to import the data from a file.

	pridėti ėjimą/add traverse	Command is used to add additional data (e.g. add inverse) from a file.
	saugoti/save	Command is used to save data in the same file used for data import.
	saugoti kaip.../save as...	Command is used to save data in a file with new name.
	Iškirpti/cut	Command is used to cut selected rows from traverse measured data dialog box.
	Kopijuoti/copy	Command is used to copy selected rows from traverse measured data dialog box.
	Įterpti/paste	Command is used to paste copied rows to selected place in traverse measured data dialog box.
	pridėti eilutę/insert row	Command is used to insert empty row at the end.
	Atstatyti/undo	Command is used to undo step.
	lyginti/adjust	Command is used to perform traverse adjustment.
	importuoti/import	Command is used to import the data from measuring devices. This function uses data import settings.
	užkrauti pagrindo taškus/import reference points	Command is used to import the reference points from selected „*.dat“ file.
	pridėti pagrindo tašką iš brėžinio/add reference point from drawing	Command is used to import the reference point from a drawing.
	tvirtų taškų Z kontrolė/z control of fixed points	Command is used to perform Z control of fixed points according to specified accuracy.
	atstumų vidurkinimas/distance averaging	Command is used to perform distance averaging according to specified accuracy.
	sužymėti ėjimą/set out traverse	Command is used to automatically set out traverse points.
	išvalyti duomenis/erase data	Command is used to erase the data and geodetic base points from surveying log.
	keisti kodus/change codes	Command is used to change the code of geodetic base point.
	surasti pagrindo ir orientavimo taškus/find reference and orientation points	Command is used to find reference and orientation points on drawings according to picket number and import to the list of reference points.
	atrinkti kodus/select codes	Command selects symbols and their descriptions according to the code on an instrument in tables of surveying log and geodetic base points, column *„Kodas“ (Code).*
	nustatymai.../settings...	Command is used to open **Geo** settings.
	pagalba./help	Command is used to call user's manual.

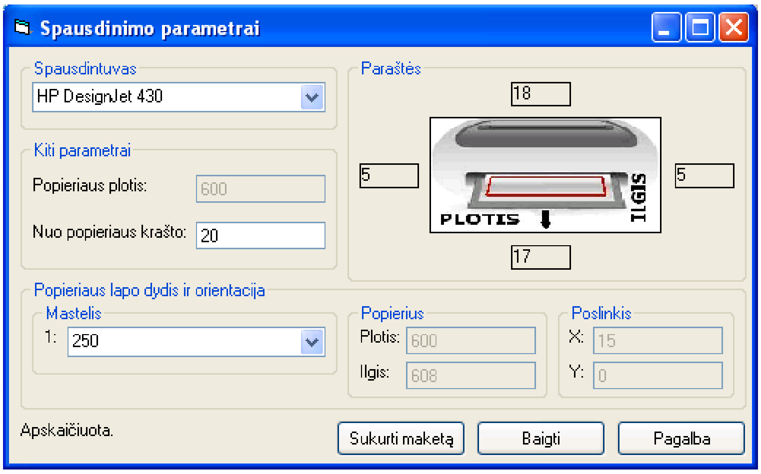
Printing parameters and plans

The function is used to print italic tables. This command allows for faster printing process and reduction of paper consumption.

The command is invoked in several ways:

- through menu *Geo → Spausdinimo parametrai ir planai (Geo → Printing parameters and plans)*.
- from toolbar „*Geo*“ by pressing .
- by entering GEOMAP_IRANKIAI_SPAUSDINIMO_PARAM to command prompt.

Three points must be indicated on the drawing under the command: *taskas1*, *taskas2* and *taskas3*. When points are indicated, dialog box „*Spausdinimo parametrai*“ (*Printing parameters*) is opened:



Dialog box „Printing parameters“

All printers from file „*Spausdintuvai2.ini*“ are listed in field „*Spausdintuvas*“ *(Printer)*. File example:

Description in file	**Explanation**
HP DesignJet 430	*printer*
420	*Paper width*
20	*Left margin*
10	*Right margin*
10	*Top margin*
10	*Bottom margin*

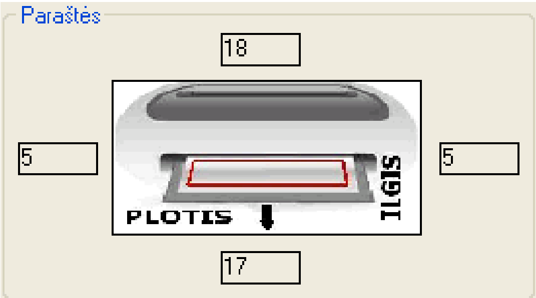
Appropriate actions must be taken to perform certain calculations: open dialog box *„Spausdinimo parametrai“ (Printer parameters)*, select another printer, press ENTER button, when mouse cursor is in the field *„Nuo popieriaus krašto“ (From the edge of the paper)*, change the scale. Hereafter calculations and actions take place in the dialog box *„Spausdinimo parametrai“(Printer parameters)*:

1. Printer parameters are set as follows:

a. If the printer is not set, select the first one from the list; the printer is described in file *„Spausdintuvas2.ini“*.Otherwise set printer is used.

b. Enter paper width parameters of the selected printer to the following fields: *Kiti parametrai → Popieriaus plotis (Other parameters → Paper width)* and *Popierius → Plotis (Paper → Width*).

c. Margins are automatically set in *„Paraštės“ (Margins)*:



Margin settings

2. If there are no entered values in *„Kiti parametrai“* (*Other parameters)*, *„Nuo popieriaus krašto“(From the edge of the paper)*, default value is set 20.

3. The following optional values are provided in the *„Mastelis“ (Scale)* list: 250; 500; 1000; 2000. Unless other value is set, default value is entered 250.

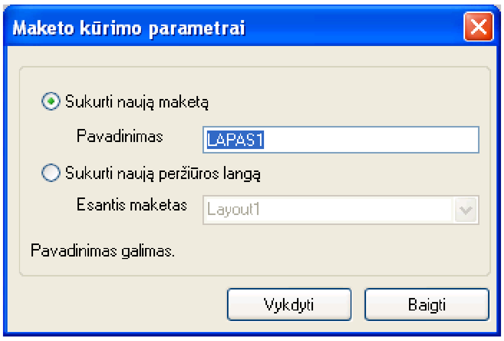
4. Paper **length** and **offset coordinates** are calculated.

When closing *„Spausdinimo parametrai“ (Printing parameters)* by pressing *„Baigti“ (End)* key, the calculations are output in command bar:

Paper size: Width x Length.

Set LTSCALE = *didKoef* before printing.

By pressing *„Sukurti maketą“ (Create a layout) Viewports* creation dialog opens:



Layout creation dialog box

Open dialog box „*Maketo kūrimo parametrai*“ *(Layout creation parameters)* and select the first available *Layout* name. All existing names are loaded to the opened list. Press „*Baigti” (End)* button, and the calculations will be output in the command bar (the same as for printing parameters). The following actions are performed by pressing „*Vykdyti*“ *(Run*):

1. If the option „*Sukurti naują maketą*“ *(Create new layout)* is selected:

a. a layout with entered name is created.

b. viewport in new layout is created.

c. **height** and **width** (*viewAukstis*, *viewPlotis*) are set for new viewport.

d. **centre coordinates** (*viewCentrasX*, *viewCentrasY*) are set for new viewport.

e. viewport is enlarged to the points: *taskas1* and *taskas2*.

f. the calculations are output in the command bar (the same as for printing parameters after pressing „*Baigti*“ *(End)*).

2. If the option „*Sukurti naują peržiūros langą*“*(Create new viewport)* is selected:

a. *Viewport* is created in selected layout.

b. height and width (*viewAukstis*, *viewPlotis*) are set for new *Viewport*.

c. centre coordinates are set for new *Viewport*.

d. *custom scale = didKoef* is set for new *Viewport*.

e. *Viewport* is enlarged to the points: *taskas1* and *taskas2*.

f. the calculations are output in the command bar (the same as for printing parameters after pressing „*Baigti*“ *(End)*).

QUESTIONS TO REPEAT:

1. What is the procedure of preparation of electronic tachometer for surveying?
2. What is a tachometry map?

3. What is the base of tachometry map?

4. What are the functions of *GeoMap* software command *traverse adjustment*?

5. What commands are used to layout the pickets?

6. How are the buildings drawn from the command *Namų braižymas ratu (Circular drawing of buildings)*?

7. What conventional symbols belong to the group of dotted symbols?

8. What conventional symbols belong to the group of linear symbols?

9. What conventional symbols belong to the group of areal symbols?

10. What is a horizontal line?

11. How is the relief represented on plans (maps)?

12. How is the graphical interpolation performed?

13. What are the main properties of horizontal lines?

14. How are the numbers written on horizontal lines?

15. What are the actions we perform while drawing horizontal lines in *GeoMap* software?

REFERENCES

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	*(a tick-mark shall mean availability of the source)*		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy*. ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	HARRY, L. *Landscape Surveying.* ISBN 9781111310608. 256 p.*	Department of Agricultural Engineering, Oklahoma State University,	√		√

			USA				
4	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√			√
5	2011	Е., В., ЗОЛОТОВА; Р., Н., СКОГОРЕВА. *Геодезия с основами кадастра.* ISBN 978-5-904954-04-8, 978-5-8291-1246-2. 416 p.*	Академи-ческий Проект, Трикста	√			√
Additional Reading							
1	1992	TAMUTIS, Zigmas, et al. *Geodezija-1* ISBN 5-420-01331-2. 292 p.	Mokslo ir enciklope-dijų leidykla	√			√
2	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.* ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	Издатель-ство "Академи -ческий Проект"	√			√
3	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.08.01:2000: statybiniai inžineriniai geodeziniai tyrinėjimai*	Valstybinė geodezijos ir kartografijos tarnyba	√			√
4	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.11.02:2000: sutartiniai topografinių planų M 1:500, 1:1000, 1:2000 ir 1:5000 ženklai*	Valstybinė geodezijos ir kartografijos tarnyba				
5	2013	*AutoCad (Autodesk Product Design Suite for Education 2013)**					
Periodicals							
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√			√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√			√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√			√
Online Information Sources							
1		http:/www.nzt					
2		http://www.infoera.lt					
3		http://www.geoportalas.lt					
4		http://www.gsb.lt					

* references for international students

Prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 5

TOPIC: SURVEYING WITH GPS DEVICES

1. The Aim of the Practical Work: to perform automatic measurement of points using GPS devices, point set out activities, surveyed point data transfer to computer, to draw up a standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 (eng. *World Geodetic System*, 1984) coordinate system.

2. The Objectives of the Practical Work: to list GPS device control functions, to prepare GPS device for work, to perform RTK survey settings, port configuration, RTK portable device settings, automatic point measurement, point set out activities, surveyed point data transfer to computer, to draw up a standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 (eng. *World Geodetic System*, 1984) coordinate system.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

The practical work is applied for international students. Lithuanian and international students prepare standard report on GPS LKS 94 coordinate system and list of coordinates of WGS 84 (eng. *World Geodetic System*, 1984) coordinate system.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
All GPS device control functions are listed, RTK survey settings are managed, Port configuration is performed, RTK base settings and RTK portable device settings are managed, point set out and automatic point measurement is performed, surveyed point data transfer to		All GPS device control functions are listed, RTK survey settings are managed, Port configuration is performed, RTK base settings and RTK portable device settings are managed, point set out and automatic point measurement is performed, surveyed point data transfer to		All GPS device control functions are listed, RTK survey settings are managed, Port configuration is performed, RTK base settings and RTK portable device settings are managed, point set out and automatic point measurement is performed, surveyed point		All GPS device control functions are listed, RTK survey settings are managed, Port configuration is performed, RTK base settings and RTK portable device settings are managed, point set out and automatic point			

computer is performed, standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 coordinate system are drawn up.	computer is performed, standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 coordinate system are not drawn up.	data transfer to computer is not performed, standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 coordinate system are not drawn up.	measurement is not performed, surveyed point data transfer to computer is not performed, standard report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 coordinate system are not drawn up.

The teacher specifies the survey object of the locality.

The survey is performed by groups of three or four students.

Each group selects a GPS device from geodetic laboratory, prepares it for work using devise user manual and surveys the specified site and its objects.

Each student individually drawns up standars report on GPS Lithuanian LKS 94 coordinate system and list of coordinates of the world WGS 84 coordinate system.

Sequence:

1. To assemble GPS device.
2. To explane control panels and keys, control principles, meanings of indicator line of GPS device.
3. To determine battery charge level.
4. To prepare GPS device for work in *Bluetooth* mode and on *GSM* network or through radio connection.
5. To check if the information about satellites is received.
6. To create new job for collection of survey data.
7. To set the height of portable GPS device and input measured value.
8. To set the type of antenna and other antenna parameters of portable GPS device.
9. To set the elevation angle of GPS satellites applied to survey.
10. To set survey reliability indexes.
11. To perform coordination of points (the number of points is specified by the lector).
12. To perform set out of points (the number of points is specified by the lector).
13. To perform importof points applying automatic and manual methods.
14. To perform reloading of points.

15. To perform review and initial processing of reloaded data.

16. To draw up standard report on GPS LKS 94 and WGS 84 coordinate systems.

17. To prepare the presentation.

Assemblage of portable GPS device

Portable GPS device consists of:

- GPS recever with GPS antenna;
- GSM//GPRS or radio antenna, if GPS receiver has itegrated radio or GSM//GPRS modems;
- data collector;
- fastening element for setting up the data collector to the stand;
- 2 m length carbon-fiber stand;

Assemblage of portable GPS device: to set up two-part carbon-fiber stand, to fasten receiver with integrated antenna (model *Trimble 5800, R6, R8*), the antenna is fastened to the receiver, to fasten data collector.

Fig. 5.1. Portable GPS receiver *Trimble R6*

The survey starts from sreation of new job. Survey data will be stored in the job.

New job creation:

1. Select *Files//New Job* in the main menu of *Trimble Survey Controller*.

2. Input the title of new job.

3. Click *Coord. Sys* to select coordinate system and then click *Next.* If there is no LKS 94 (Lithuanian coordinate system), select it from the library.

4. Measuring units are set by clicking *Units* key.

5. Click *Accept* to save the job after the settings are made:

1. Select *Files//Open Job* in the main menu of *Trimble Survey Controller.*

2. Select the required job, mark it with a pen and click *Select.* The title of the job will appear on the upper information bar of *Trimble Survey Controller* software.

Job deletion:

1. Select *Files//Open Job* from the main menu of *Trimble Survey Controller,* mark the job with directional buttons or by clicking and holding for some seconds special pen on active touch screen. The job is deleted by clicking and holding for some seconds special pen on active touch screen. By quick click the job will be opened and activated.

2. Click *Delete, Yes* for deletion or *No* **–** to cancel.

Portable GPS device setting

Configurations of Portable GPS device for *RTK* surveying:

1. Select *Configuration /Survey Styles / RTK/ Rover options* in the main box of *Trimble Survey Controller* software .

2. Made settings are provided in table 5.1..

Table 5.1.

Portable GPS device settings

Survey Type	RTK
Broadcast Format	CMR+
Use Station index	Any
Promt Station Index	Do not put a tick mark
Satellite Diferencini	Off
Elevation Mask	15°
PDOP Mask	6.0
Antenna:	
Type	Selected from the list according to used GPS device model
Measured to	Bottom of antenna mount
Antena Height	2.000 m, if the device is fastened to the stand, of 2 m in length
Šeriai number	Device series number is entered
Trackπio:	
Use L2C	Yes
L2C	(if device supports L2C frequency) to put a tick mark

Preparation of portable GPS device for work on *GSM* network

To transmit the corrections of portable GPS device in real time, *GSM* or radio connection is used. *GSM* connection is set as follows:

1. Select *Configuration /Survey Styles / RTK/ Rover Radio* in the main menu box of *Trimble Survey Controller* software.

2. Customized settings are provided in table 5.2.

Table 5.2.

Transmission of corrections in real time through *GSM* connection

Type	Trimble internal
Method	GSM dial up
Name to dial	?
Number to dial	Data number
Modem PIN	Empty
Init String	?
Hang UO	ATHO
Dial Prefix	AT D
Dial Suffix	?
Post Connect	?
Send User Identify In for	Do not put a tick mark varnele

Settings for real time transmission of the coorections of portable GPS device though integrated radio system are as follows:

1. Select *Configuration /Survey Styles / RTK/ Base Radio*in the main menu box of *Trimble Survey Controller* software.

2. Customized settings are provided in table 5.3.

Table 5.3.

Transmission of corrections in real time through radio connection

Type	T RIMT AL K 450S
Frequency	443.8570 MHz
Chanel Spacine	12.5 KHz
Power Output	0.5 W

To start survey with portable GPS device

Survey with portable GPS device in *RTK* mode:

1. Make sure if the created job is active; its title is in the upper information line.

2. Select *Survey* from the main menu.

3. If surveying in *RTK* mode, make sure the corrections ar received from GPS network through radio or *GSM* connection.

4. If automatic initialisation failed, initialise mannualy.

5. After survey initialisation select survey methods: point measurement *Measure Points* or stake out of points *(Stakeout).*

Input of heights of stand for portable GPS device

1. Select *Configuration /Survey Styles* / in the main menu of *Trimble Survey Controller,* select survey mode/ *Rover options.*

2. When using 2 m long carbon fiber stand, input 2.000 in the field *Antenna Height*. Device height will be constant during survey of each point.

3. If is is necessary to chanhe the height during survey, change it manually by inputing device height when filling in surveyed point parameters.

Input of survey reliability of portable GPS device

Survey reliability is defined by *PDOP* index. *PDOP* stands for positional dilution of precision. It indicates the accuracy of position based on the number of satellites and the geometry of satellite positions. From a geometrical point of view *PDOP* is proportional to the used divided by the volume of pyramid, formed by lines drawn from four observed satellites to GPS antenna. Lower number – to 6 means more accurate survey data, higher than 6 – less accurate data. Low *DOP* values mean thet satellites are widely spread in relation to surveyed point, and high values – vice virsa. *PDOP* involve vertical and horizontal $PDOP^2 = HDOP^2 + VDOP^2$

PDOP Mask setting:

1. Select *Configuration /Survey Styles / RTK/ Rover options* in th main woindow of *Trimble Survey Controller* software.

2. Input 6.0 value in the field „*PDOP Mask*“. *PDOP Mask* – maximum *DOP* value under which the device proceeds with calculation of positions.

Input of elevation angle of portable GPS device

Elevation angle of portable GPS device is set by configuration of each survey mode:

1. Select *Configuration /Survey Styles / Rover options* in the main wondow of *Trimble Survey Controller* software.

2. Set elevation angle in the field *Elevation Mask* and save the changes.

Input of antenna type and configuration of portable GPS device

Antenna type of portable GPS device is set by configuration each syrvey mode:

1. Select *Configuration /Survey Styles / Rover options* in the main wondow of *Trimble Survey Controller* software.

2. Select used antenna from the list in the field *Antena type* and save the changes.

Coordination of points

After preparatory works are completed, coordination of points using portable GPS device may be started:

1. Select *RTK* in the main menu of *Trimble Survey Controller* and click *Start Survey*.

2. Select *Measure Points* from *Survey* menu.

3. Number of satellites is observed. It is not allowed to perform *RTK* surevy when less than five satellites are within the visibility zone of GPS device. Satisfied with the accuracy enter parameters of surveyed point: point number *Name*, point code *Code* – selected from codes library or input manually, if necessary – stand height is changed by entering the value in *Antenna Height*.

5. Click *Measure* in the right bottom corner of the screen, observe point measurement time reading. After the measurement click *Store* and save the data. When data is saved the measurements continue by repeating steps 4 and 5.

Stake out of points

1. Select *Stakeout* from *Survey* menu when survey in *RTK* mode is started.

2. List of anticipated stake out points is activated *Stake out points list*.

3. To add to the list click *Add*.

4. To stake out all points select *All Points*.

5. To stake out specific point mark it inn the list and click *Stakeout* in the right bottom corner of the screen.

6. Keep the data collector in front of you, move to designated direction taking into account the distance to the stakeout point.

7. When the distance to the stakeout point is 3 m, directional arrow is changed with target - *course* view is activated.

8. When the distance to stakeout point is about 30 cm, *fine* view is activated.

9. During ht observation of data collector screen the device must be set so that the cross would be right on the location of stakeout point.

10. Mark the point.

11. Fpr accuracy checking the point is recoordinated *as-stakeout*, by clicking *Accept* or *Measure*. If other point is staked out, the stakeout point dessapers from the list of points. Repeat the steps tostake out other points.

Import of points or manual input to portable GPS device

Manual input of point parameters to GPS device memory:

1. Select *Key In / Points* in the main menu of *Trimble Survey Controller*.

2. Enter point name.

3. Enter other parameters: *X*, *Y*, *Z*, *Code*.

4. The point is saved, click *Store* and continue work.

The data is imported to data collector using *Trimble Geomatics Office* software in * *CSV* format:

1. Imported data must be in *TGO* file.

2. Data collector must be connected to computer.

3. Select *File / Export,* click *Comma delimited* c*oordinate file to Surbey controler (*CSV)*in dialog box, select *Survey Controller on ActiveSync* and click *Open* (*CSV* file must include: number, *X, Y*, *Z*, code)

The data are exported to the internal memory of data collector.

4. To import *.*CSV* files available on data collector to new job or previous job use *import* function (*File / Import/Export*).

Measurement data transfer

Point measurement data are transferred to computer. Matavimo duomenims perkelti iš valdiklio, Use *Microsoft ActiveSync* software to transfer measurement data from controller:

1. *Microsoft ActiveSync* software must be installed on the computer.

2. When the data collector is connected to the computer, the following box appears (fig. 5.2.).

Fig. 5.2. Measurement data transfer software

3. Select *Cancel* to connect as a *Guest*.

After connection of the device to the computer *Trimble Geomatics Office* software is used for data processing:

1. *Trimble Geomatics Office* software is activated (*Start / Programs / Trimble*

Office / Trimble Geomatics Office / Trimble Geomatics Office).

2. New file is created in order to transfer surveyed points from the data collector to the computer.

Creation of project: Activate program → *New Project*, type the title of project in box *Name*. *Template* → LKS 94. At the option *New* select *Project.* Open the box *Project properties* → *Coordinate system* and check if LKS 94 coordinate system is selected, if not – click *Change*, *Select Coordinate system* box will open, select coordinate system and click *Finish.* Close *Project properties* dialog box by clicking *OK.*

Data import from data collector: Go to *File* → *Import* and click *Survey devices* → *OK* in appeared dialog box. Find *Survey Controller on ActiveSync* and click *OPEN.* After the sata are trasferred, in box *Project koordinates system* → select *Keep the existing Project definition* → *OK.* Coordinate system of the software is used for surveyed points because it is more widely described then on the software for field data storage of the data collector. In *DAT Chekin* dialog box the information about surveyed points is provided → *OK.* The data were collected in RTK survey mode, therefore there is no need of additional data processing; the data may be exported for later processing in a desired format.

Standartinė GPS ataskaita

Darbo pavadinimas: ausssyte

Koordinačių sistema: Lithuania

Zonos pavadinimas: LKS94

Laiko zona: Lokalinė

Taškas	X	Y	H	Data	Laikas	Epocha	Max. PDOP	Hor. tiksl.	Vert. tiksl.
KAUN	6085562.947	498690.049	87.352	03.04.2012	10:46:14		?	?	?
1p	6076392.650	489789.813	78.647	03.04.2012	10:54:09	6	1.556	0.009	0.012
1q	6076392.653	489789.831	78.641	03.04.2012	10:54:28	6	1.543	0.008	0.012
1r	6076392.654	489789.824	78.643	03.04.2012	10:54:39	6	1.529	0.008	0.012
1s	6076392.643	489789.833	78.644	03.04.2012	10:54:57	6	1.510	0.008	0.012
1t	6076392.642	489789.832	78.658	03.04.2012	10:55:17	6	1.520	0.008	0.012
1u	6076392.632	489789.823	78.668	03.04.2012	10:55:34	6	1.520	0.008	0.012
1v	6076392.641	489789.822	78.661	03.04.2012	10:55:54	6	1.525	0.008	0.012
1w	6076392.646	489789.822	78.666	03.04.2012	10:56:12	6	1.563	0.008	0.012
1x	6076392.653	489789.815	78.670	03.04.2012	10:56:30	6	1.524	0.008	0.012
1y	6076392.662	489789.815	78.674	03.04.2012	10:56:44	5	1.520	0.008	0.012
2p	6076186.670	489692.886	78.447	03.04.2012	11:02:09	55	1.921	0.096	0.145
2q	6076186.664	489692.887	78.461	03.04.2012	11:02:27	6	1.229	0.006	0.008
2r	6076186.667	489692.888	78.467	03.04.2012	11:02:38	6	1.252	0.007	0.010
2s	6076186.674	489692.874	78.466	03.04.2012	11:02:57	6	1.299	0.008	0.010
2t	6076186.664	489692.873	78.470	03.04.2012	11:03:15	6	1.323	0.008	0.010
2u	6076186.662	489692.864	78.472	03.04.2012	11:03:32	5	1.335	0.008	0.010
2v	6076186.663	489692.864	78.470	03.04.2012	11:03:49	6	1.342	0.008	0.010
2w	6076186.662	489692.873	78.471	03.04.2012	11:04:06	6	1.346	0.008	0.010
2x	6076186.660	489692.873	78.472	03.04.2012	11:04:21	6	1.330	0.008	0.010
2y	6076186.659	489692.876	78.467	03.04.2012	11:04:40	6	1.346	0.007	0.010
3p	6076383.326	489657.069	82.348	03.04.2012	11:10:26	6	1.254	0.007	0.010
3q	6076383.326	489657.065	82.349	03.04.2012	11:10:39	5	1.291	0.007	0.010
3r	6076383.327	489657.069	82.343	03.04.2012	11:10:55	5	1.302	0.007	0.010
3s	6076383.330	489657.068	82.346	03.04.2012	11:11:08	6	1.323	0.007	0.010
3t	6076383.332	489657.068	82.348	03.04.2012	11:11:21	6	1.332	0.006	0.009
3u	6076383.332	489657.069	82.346	03.04.2012	11:11:36	6	1.326	0.008	0.010
3v	6076383.328	489657.068	82.344	03.04.2012	11:11:48	6	1.338	0.008	0.010
3w	6076383.328	489657.064	82.352	03.04.2012	11:12:01	6	1.341	0.008	0.010
3x	6076383.326	489657.062	82.354	03.04.2012	11:12:17	6	1.334	0.008	0.010
3y	6076383.326	489657.060	82.349	03.04.2012	11:12:30	6	1.345	0.008	0.011
4p	6076423.689	489629.772	79.516	03.04.2012	11:14:13	5	1.366	0.007	0.010
4q	6076423.686	489629.776	79.501	03.04.2012	11:14:27	6	1.409	0.008	0.011
4r	6076423.676	489629.798	79.525	03.04.2012	11:14:47	5	1.362	0.007	0.010
4s	6076423.673	489629.798	79.522	03.04.2012	11:15:01	5	1.375	0.008	0.011
4t	6076423.673	489629.796	79.517	03.04.2012	11:15:19	6	1.421	0.008	0.011
4u	6076423.669	489629.796	79.525	03.04.2012	11:15:36	6	1.420	0.008	0.011
4v	6076423.676	489629.798	79.523	03.04.2012	11:15:49	6	1.433	0.008	0.011
4w	6076423.675	489629.800	79.517	03.04.2012	11:16:02	6	1.438	0.008	0.011
4x	6076423.685	489629.806	79.524	03.04.2012	11:16:14	6	1.439	0.008	0.011

Fig. 5.3. Standard GPS report

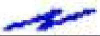
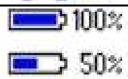
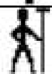
ADDITIONAL MATERIAL FOR COMPLETION OF THE PRACTICAL WORK

Trimble Survey Controller software is controlled with the help of active touch screen. Specal pen is used for the purpose complete with *Trimble TSC2* data collector. The *Trimble Survey Controller* software is activated through *Start* menu, all desired functions are controlled by touching the screen with the pen.

Main control of GPS device is performed by the data collector. All measurements and parameters are recorded to the field data storge software *Trimble Survey Controller*.

Indicators of *Trimble Survey Controler* field software may be observed only if the software is activated on the data collector. Meanings of the indicators depen on what devices are connected to the data collector (controller). Indicators of GPS device software and their meanings are provided in fig. 5.4..

GPS device software indicators

Indikatorius	Reikšmė
	Duomenų kaupiklis ima energiją iš išorinio šaltinio
	Duomenų kaupiklio baterija kraunama
	Baterijos lygis yra 100% arba 50 % . Baterijos viršutinis rodmuo yra duomenų kaupiklio, apatinis – išorinio prietaiso, sujungto su duomenų kaupikliu
	Duomenų kaupiklis valdo *Trimble 5800*GPS imtuvą
	Duomenų kaupiklis valdo *Trimble R7* GPS imtuvą
	Duomenų kaupiklis valdo *Trimble R8* GPS imtuvą
	Duomenų kaupiklis valdo *Trimble 5700*GPS imtuvą
	Duomenų kaupiklis valdo *Trimble 4800*GPS imtuvą
	Duomenų kaupiklis valdo *Trimble 4700*GPS imtuvą
 1.000	Duomenų kaupiklis valdo *Trimble 4800*GPS imtuvą. Imtuvo aukštis matomas dešinėje
 	Be imtuvo, yra prijungta išorinė antena. Jos aukštis matomas dešinėje indikatoriaus pusėje
	Matuojamas stacionarus taškas
	Priimami radijo duomenų paketai
 	Priimami mobiliojo ryšio modemo signalai Kai ryšys nutrūksta, indikatorius perbraukiamas
	Priimami *WAAS/EGNOS* signalai
	Palydovų skaičius, stebimas imtuvo, pateikiamas indikatoriaus dešinėje
	Matuojant tikruoju laiku GPS imtuvas (roveris) bazinio imtuvo siunčiamas pataisas priima internetinio ryšiu (GPRS)

Indicator **Meaning**

Data collector is energized by external source
Battery is charging
Battery charge is 100% or 50%. The upper indication is for the data collector, the bottom – external device connected to the collector.
Data collector controls Trimble 5800GPS receiver
Data collector controls Trimble R7 GPS receiver
Data collector controls Trimble R8 GPS receiver
Data collector controls Trimble 5700 GPS receiver
Data collector controls Trimble 4800 GPS receiver
Data collector controls Trimble 4700 GPS receiver
Data collector controls Trimble 4800 GPS receiver. Height of the receiver is on the right
Apart from the receiver, antenna is connected. Height of antenna is on the right
Stationary point is measured
Receiving of radio data batches
Receiving of mobile connection modem signals

When connection is interrupted the indicator crossed
Receiving of of *WAAS/EGNOS* signals
Number of satellites observed by receiver, on the right of indicator
In real time survey the GPS receiver receives corrections from base receiver through internet connection (GPRS)

Fig. 5.4. GPS device software indicators

Text indicators in the bottom of the screen of data collector provide information about performed activities or current errors. Text indicators of GPS device software and their meanings are provided in table 5.4..

Table 5.4.

Text indicators

Text indicator	Explanation
No Survey	GPS device is connected to data collector, but survey mode is not selected
RTK:Fixed	Performed RTK survey are initialised, *L 1* is *fixed - centimeter-level*
RTK:Float	Performed RTK survey are non- initialised, *L 1* is not fixed *(float)*
RTK:Check	RTK survey performed –initialisation is verified
RTK:Auto	Radio connection was lost during RTK survey – autonomous positioning is performed
RTK:WAAS	Radio connection was lost during RTK survey, solution - GPS survey is performed with *WAAS/EGNOS*
FastStatic	Selected survey mode is fast static *{FastStatic)*
PP differential	Results are processed after survey
RT differential	Survey is performed in *real- time differential* mode
In fill:Fixed	Performed kinematic survey is initialised and after processing ionosphere unaffected *L 1* fixed solution with cm accuracy is obtained
In·ifill	Performed survey is differential and a session is performed with data collection for post-processing *(post-piocessing)*

Bluetooth wireless connection in GPS device and data collector allow for data exchange without a cable. The capabilities of data collector with *Bluetooth* connection:

- connection with other data collector (for data exchange);
- control *Trimble R8, R6, 5800* GPNS devices;
- control distance metering units.

Configuration of *Bluetooth* port connecting the data collector with *Trimble R8*, *R6*, *5800* GPNS devices:

- connect device with data collector;

- activate *Trimble Survey Controller* software and select *[Configuration / Controller / Bluetooth]* from the main menu;

- click *Config* to activate *Bluetooth* port: watch *TSC2* data collector to ensure that *[Turn on Bluetooth]* and *[Make this devise discoverable to other devices]* references are marked.

- scan of *Bluetooth* evices is activated on the data collector: select *[Devises]* on *TSC2* controller and then select *[New];*

- *Trimble Survey Controller* software is used to find *Bluetooth* devices located at a distance of up to 10 m;

- after scan select device to connect with data collector and click *[Next];*

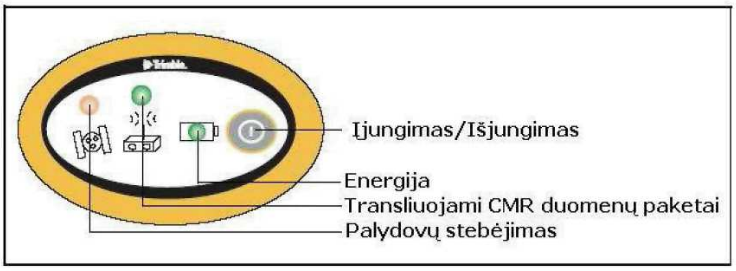
- if connection to GPS device is performed there is no need to enter access code – click *[Next];*

- enter device name and click *[Finish];*

- click *[OK] Trimble Survey Controller;*

- select device to measure with in the field *Reciever*. Select *[Accept]* and software will automatically connect to defined GPS device.

The information provided by LEDs of *Trimble* GPS device is provided in fig. 5.5. and table 5.5..



On/Off
Energy
Translation of CMR data
Observation of satellites

Fig. 5.5. LED information if the device

Trimble GPS device has one functional – On // Off button. Functions of the button:

- To turn on the GPS device press OFF button for 2 s;

- to delete ephemeris file – press for 15 s;

- to restart the device with factory settings – press for 15 s;

- to delete used files – press for 30 s.

LED information is provided in table 5.5..

Table 5.5.

LED information

GPS device status	Energy	Radijo duomenų Perdavimo	Palydovų sekimo
	Green	Green	Yellow
OFF	-	-	-
ON: batteries are fully charged	lighting	-	-
ON: batteries are running down	fast blinking	-	-
Four and more satellites are observed	lighting	-	fast blinking
Less then four satellites are observed	lighting	-	slow blinking
Internal data collection	Blinking each 3 s	-	-
Internal translation	-	lighting in the cource of translation	-
Radio data trasfer	lighting	slow blinking	-
Radio data are not received	lighting	Not lighting	-

Work management

To star the survey job must be created for measurement data collection.

Creation of new job:

1. Select *Files // New Job* in the *Trimble Survey Controller* main manu.
2. Type in job title.
3. To select coordinate system click *Coord. Sys,* then – *Next.*
4. If there is no LKS'94 coordinate system, select it from the library.
5. To change metering units (dimensions) of the created job click *Units* .
6. When settings are made click *Accept* to save the job.

Continuing existing job:

1. Select *Files//Open Job* from the *Trimble Survey Controller* main menu.
2. Select the job to continue with, mark with a pen and click *Select*.

The title of continuing job will be visible on the upper information bar of the *Trimble Survey Controller* software.

Deletinf the job:

1. Select *Files//Open Job* from the *Trimble Survey Controller* main menu.

If the job to be delated is not marked, mark it using directional buttons or by pressing and holding the pen on active touch screen.

2. Click *Delete* and *Yes* to confirm deletion or *No* – to cancel deletion.

Creating export file

Export of points in desired format is performed, automatically input to C:\ *Trimble Geomatics Office / Projects /* ttle of created project / *Export.*

Determination of the structure of exposrt file data

The structure of export file data is individually defined according to the method of further data processing. To export the data click *File/Export* and select the format of data from the ones seggested:

- if data were processed by *ArcGIS* software, export in *ArcView shape file points – (*.dbf, *.shp, *.shx).*

- if data were processed by *CAD* software, export in *(*.dxf, *.CSV* arba *.txt)* formats.

After format is selected, chose required standard of data export and click *OK*, enter the title in appeared dialog box and save.

File export procedure

1. New project (file) is created in *Trimble Geomatics Offise* data processing software to upload surveyed points.

2. Survey results are downloaded from the data collector to *Trimble Geomatics Office* software for field data processing.

3. Data are exported under selected format.

QUESTIONS TO REPEAT:

- What are the GPS device indicators for?
- Describe the meanings of LEDs defining the status of GPS device.
- How does GPS work?
- What is the difference between static and kinematic survey methods?
- How are the data collected by GPS device?
- How to create a new job?
- What parameters do determine the accuracy of GPS survey?
- How are the points coordinated by GPS device?
- How are the points staked out by GPS device?

- How to prepare the standard GPS report**?**

REFERENCES

Seq. No.	Publishing year	Information source (publication) author, title and identification number	Publishing location and house	*(a tick-mark shall mean availability of the source)*		
				Kaunas College library	Study Rooms	Other libraries
Key Information Sources						
1	2008	ŽIVATKAUSKAS, Aurelijus, et al. *Geodezija: mokymo(si) priemonė.* ISBN 978-9955-511-87-8. 329 p.	Vilnius. UAB „Vaistų žinios“	√		√
2	2012	Alexander, Ross, CLARKE. *Geodesy.* ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
3	2012	HARRY, L. *Landscape Surveying.* ISBN 9781111310608. 256 p.*	Department of Agricultural Engineering, Oklahoma State University, USA	√		√
4	2012	Charles, D., GHILANI et al. *Elementary Surveying* . ISBN 978-0-13-255434-3. 984 p.*	Westford United States of America	√		√
5	2011	Е., В., ЗОЛОТОВА; Р., Н., СКОГОРЕВА. *Геодезия с основами кадастра.* ISBN 978-5-904954-04-8, 978-5-8291-1246-2. 416 p.*	Академи-ческий Проект, Трикста	√		√
Additional Reading						
1	1998	SKEIVALAS, Jonas. *Elektroniniai geodeziniai prietaisai* ISBN 9986-05-713-2. 193 p.	Technika	√		√
2	1996	TAMUTIS, Zigmas. ir kiti. *Geodezija-2* ISBN 5-420-01331-2. 384 p.	Mokslo ir enciklope-dijų leidykla,	√		√
3	2011	АЛЬБЕРТ, ГАМЗАТОВИЧ, ЮНУСОВ, и др. *Геодезия.* ISBN: 978-5-8291-1326-1, 978-5-98426-108-1. 409 p.*	Издатель-ство "Академи -ческий Проект"	√		√
4	2012	TORGE, WOLFGANG; MÜLLER, JÜRGEN. *Geodesy.* ISBN 978-3-11-020718-7. 539 p.*	University of Hannover, Germany.	√		√
5	2003	ERIK W. GRAFAREND, FRIEDRICH W. KRUMM, VOLKER S. SCHWARZE. *Geodesy – The Challenge of the 3rd Millennium.* ISBN-10: 3642077331. 487 p.*	Springer – Verlag Berlin Heidelberg	√		√
6	2000	Geodezijos ir kartografijos techninis reglamentas. *GKTR 2.08.01:2000:*	Valstybinė geodezijos ir	√		√

		statybiniai inžineriniai geodeziniai tyrinėjimai	kartografijos tarnyba			
Periodicals						
1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
Online Information Sources						
1		http://www.nzt				
2		http://www.topcon.lt				
3		http://www.gpspartneris.lt				
4		http://www.infoera.lt				
5		http://www.geoportalas.lt				
6		http://www.gps.lt				
7		http://www.glonas-center.ru				
8		http://www.unavco.org				
9		http://www.navstar.com				
10		http://www.esa.int/esaNA/galileo.html				
11		http://www.gsb.lt				

* references for international students

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Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 6

TOPIC: INVERSE AND DIRECT ANGULAR INTERSECTION SOLUTIONS

1. The Aim of the Practical Work: to apply geodetic and mathematical methods in determination of point coordinates.

2. The Objectives of the Practical Work: to perform geodetic surveying, to calculate point coordinates, to apply inverse (point displacement) and direct intersection calculation methods.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

The calculations are performed according to the original coordinates of the world coordinate system *WGS 84* (eng. *World Geodetic System*, 1984), therefore the practical work is applied both for Lithuanian and international students.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Point coordinates are calculated applying the calculations methods of inverse and direct intersection, the reliability of results is evaluated.		Point coordinates are calculated applying the calculations methods of inverse and direct intersection, the reliability of results is not evaluated.		Point coordinates are calculated applying the calculations methods of inverse and direct intersection, the calculations have errors, the reliability of results is not evaluated.		Point coordinates are calculated applying the calculations methods of inverse and direct intersection, the calculations are wrong, the reliability of results is not evaluated.			

INVERSE ANGULAR INTERSECTION

(DISPLACEMENT OF POINT COORDINATES FROM POINT *M* TO POINT *B*)

When there are three coordinated points (directions) on the locality and the coordinates of required point must be found, two points must be set out, two bases must be created and lengths of datum lines must be measured.

Procedure:

1. To calculate the distance from survey marker *401* to survey marker *3* of triangle *1, 401,3*. The difference of calculated distances may differ by 20 cm. Distance average value is used for further calculations. 2. To calculate the direction angle value of line *401,2* and compute the length of the line according to three formulas. The calculated distances may differ by 50 cm. Average value of three measurements is used for further calculations.

3. To calculate 402 and *401* values of triangle angles *401,402,3*.

4. To calculate the direction angle of line *401,3*.

5. To calculate the coordinates of point *3*.

6. To calculate the value of direction angle *3, 402* of the line.

7. To check the calculations of the value of direction angle *3,402*. The values may differ by 5 sec.

Further, the calculations are performed according to the second triangle *401,403,3,* the procedure of calculations is similar to the abovementioned.

Angles between coordinated directions and datum lines are measured. Datum lines are created so that it would be easy to measure their length and angles to coordinated survey markers (peaks) (fig. 6.1.).

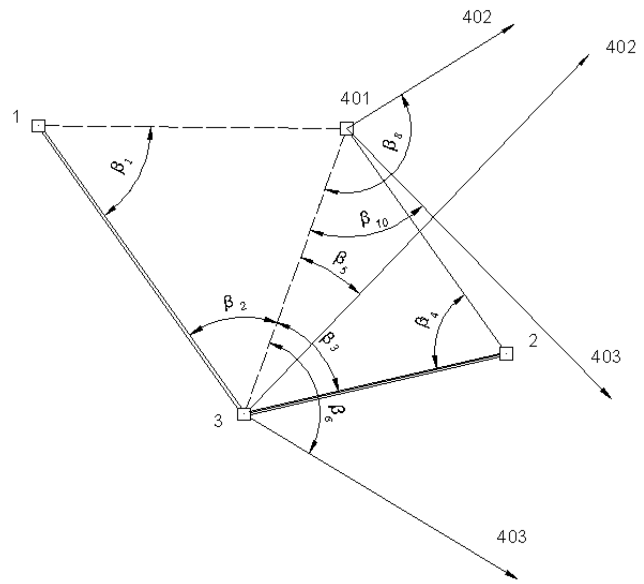

Fig. 6.1. Scheme of coordination of points by inverse intersection

Measurement data are provided in table 6.1.

Table 6.1.

Measurement data

Angles	Angle values
ß$_1$	53°56'39"
ß$_2$	55°15'05"
ß$_3$	57°14'06"
ß$_4$	67°38'45"
ß$_5$	24°11'27"
ß$_6$	101°29'15"
Base	**Base length, m**
$S_{1,3}$	222,038
$S_{2,3}$	168,685

Coordinates of survey markers are provided in table 6.2.

Table 6.2.

Coordinates of survey markers

	Survey marker	*401*	*402*	*403*
Coordinates *WGS 84*, m	*X*	6182380,266	6185467,458	6180342,816
	Y	500361,025	503444,321	503361,086

Mathematical treatment of data is performed according to the results of geodetic measurement.

1. The distance between marker *401* to marker *3* of triangle *401,3,1* is calculated :

$$S_{401,3} = \frac{S_{1,3} \cdot \sin \beta_1}{\sin(\beta_1 + \beta_2)} = \frac{222{,}038 \cdot \sin 53°56'39''}{\sin(53°56'39'' + 55°15'05'')} = 190{,}073 \text{ m.} \qquad 6.1.$$

2. The distance between marker *401* to marker *3* of triangle *401, 2,3* is calculated:

$$S_{401,3} = \frac{S_{2,3} \cdot \sin \beta_4}{\sin(\beta_3 + \beta_4)} = \frac{168{,}85 \cdot \sin(67°38'45'')}{\sin(57°14'06'' + 67°38'45'')} = 190{,}175 \text{ m.} \qquad 6.2.$$

3. The difference between the distances is less than 20 cm, so average value is calculated:

$$S_{401,3} = 190{,}124 \text{ m.} \qquad 6.3.$$

4. The direction angle of line *401,402* is calculated:

$$\text{arc tg}\ \alpha_{401,402} = \frac{\Delta Y_{402,401}}{\Delta X_{402,401}} = \frac{3083{,}296}{3087{,}192} = 44°57'50'' \qquad 6.4.$$

5. The length and average value of line *401,402* is calculated:

$$S_{401,402} = \frac{\Delta X_{402,401}}{\text{coc}\ \alpha_{401,402}} = \frac{3087{,}192}{\cos\ (44°57'50'')} = 4363{,}195 \text{ m.} \qquad 6.5.$$

$$S_{401,402} = \frac{\Delta Y_{402,401}}{\sin \alpha_{401,402}} = \frac{3083{,}296}{\sin\ (44°57'50'')} = 4363{,}195 \text{ m.} \qquad 6.6.$$

$$S_{401,402} = \sqrt{\Delta X_{402,401}{}^2 + \Delta Y_{402,401}{}^2} = \sqrt{3087{,}192^2 + 3083{,}296^2} = 4363{,}195 \text{ m.} \qquad 6.7.$$

6. The difference between the distances is less than 20 cm, so average value is used:

$$S_{401,402} = 4363{,}195 \text{ m.} \qquad 6.8.$$

7. The value of angle *401,402,3* (β_7) is calculated:

$$\sin \beta_7 = \frac{S_{401,3} \cdot \sin \beta_5}{S_{401,402}} = \frac{190{,}124 \cdot \sin\ (24°10'23'')}{4363{,}195} = \sin 1°01'21''. \qquad 6.9.$$

8. The value of angle β_8 is calculated:

$$\beta_8 = 180° - \beta_5 - \beta_7 = 180° - 24°11'27'' - 1°01'21'' = 154°47'10''. \qquad 6.10.$$

9. The value of direction angle of line *401,3* is calculated:

$$\alpha_{401,3} = \alpha_{401,402} + \beta_8 = 44°57'50'' + 154°47'10'' = 199°45'00'' \qquad 6.11.$$

10. The coordinates of marker *3* are calculated:

$$X_3 = X_{401} + S_{401,3} \cdot \cos\alpha_{401,3} = 6182380{,}266 + 190{,}124 \cdot \cos(199°45'00'') = 6182201{,}326 \text{ m} \quad 6.12.$$

$$Y_3 = Y_{401} + S_{401,3} \cdot \sin\alpha_{401,3} = 35500361{,}025 + 190{,}124 \cdot \sin(199°45'00'') = 500296{,}779 \text{ m} \quad 6.13.$$

11. The value of direction angle of line *3, 402* is calculated:

$$\text{arc tg } \alpha_{3,402} = \frac{\Delta Y_{402,3}}{\Delta X_{402,3}} = \frac{3147{,}542}{3266{,}132} = 43°56'27'' \quad 6.14.$$

12. Check computation of the direction angle of line *3,402*:

$$\alpha_{3,402} = \alpha_{401,3} + 180° + \beta_5 = 199°45'00'' + 180° + 24°11'27'' = 43°56'27''. \quad 6.15.$$

Further the calculations according to the triangle *401, 403, 3* are performed.

13. Direction angle of line *401,403* is calculated:

$$\text{arc tg } \alpha_{401,403} = \frac{\Delta Y_{403,401}}{\Delta X_{403,401}} = 124°10'55'' \quad 6.16.$$

14. The length and average value of line *401,403* is calculated:

$$S_{401,403} = \frac{\Delta X_{403,401}}{\text{coc } \alpha_{403,401}} = 3626{,}509 \text{ m}. \quad 6.17.$$

$$S_{401,403} = \sqrt{\Delta X_{403,401}{}^2 + \Delta Y_{403,401}{}^2} = 3626{,}509 \text{ m}. \quad 6.18.$$

$$S_{401,403} = \sqrt{\Delta X_{403,401}{}^2 + \Delta Y_{403,401}{}^2} = 3626{,}509 \text{ m}. \quad 6.19.$$

15. The difference between the distances is less than 20 cm, so average value is used:

$$S_{401,402} = 3626{,}509 \text{ m}. \quad 6.20.$$

16. *401,403,3* (β$_9$) angle value is calculated:

$$\sin\beta_9 = \frac{S_{401,3}\cdot\sin\beta_6}{S_{401,403}} = \sin 2°56'42''. \qquad 6.21.$$

17. β$_{10}$ angle value is calculated:

$$\beta_{10} = 180° - \beta_6 - \beta_9 = 154°47'12''. \qquad 6.22.$$

18. Value of direction angle of line *401,3* is calculated. The value may differ from the earlier measured up to 5 s.

$$\alpha_{401,3} = \alpha_{401,402} + \beta_8 = 44°57'50''+154°47'12''= 199°45'02'' \qquad 6.23.$$

19. The coordinates of marker *3* are calculated:

$$X_3 = X_{401} + S_{401,3}\cdot\cos\alpha_{401,3} = 6182380{,}266 + 190{,}124\cdot\cos(199°45'02'') = 6182201{,}327\ \text{m} \qquad 6.24.$$

$$Y_3 = Y_{401} + S_{401,3}\cdot\sin\alpha_{401,3} = 500296{,}777\ \text{m} \qquad 6.25.$$

20. The value of direction angle of line *3, 403* is calculated:

$$\text{arc tg}\ \alpha_{3,403} = \frac{\Delta Y_{403,3}}{\Delta X_{403,3}} = 121°14'13' \qquad 6.26.$$

21. Check calculation of direction angle of line *3,403*:

$$\alpha_{3,403} = \alpha_{401,3} + 180° + \beta_6 = 121°14'13'' \qquad 6.27.$$

22. Average coordinates are calculated:

X_3 = 6 182 201,327 m; Y_3 = 500 296,777 m. 6.28.

DIRECT ANGULAR INTERSECTION

Angles are measured for determination of ground point coordinates by geodetic intersection– angular intersection. Angular intersections are divided into direct and inverse. The intersection is single when only required number of reference points and measurements is applied. When there are more reference points and measurements than it is actually required, the intersection is multiple. The multiple intersection is more precise because of additional measurements, therefore the results are more reliable. *PK-77* picket coordinates are calculated according to the coordinates of three points and measured *A, B, C* angles.

Procedure:

1. To calculate the coordinates of point *PP-77* of triangle *A, B, PP-77*.
2. To check the calculation of the coordinates of point *PP-77* of triangle *C, B, PP-77*.
3. To evaluate the reliability of calculated coordinates, they may differ by 50 cm.
4. To calculate average coordinates of point *PP-77*.

The drawing is provided in fig. 6.2.

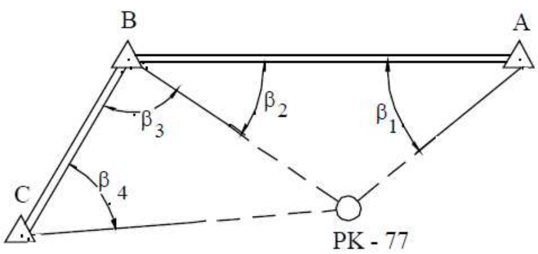

Fig. 6.2. Scheme of direct angular intersection

Measurement data are provided in table 6.3.

Table 6.3.

Measurement data

Points	Angles
$ß_1$	33°34'06"
$ß_2$	26°01'18"
$ß_3$	82°10'47"

ß₄	57°24'25"

Coordinates of survey markers are provided in table 6.4.

Table 6.4.

Coordinates of survey markers

Points	Coordinates *WGS 84*, m
x_A	6086116,04
x_B	6086517,83
x_C	6084516,92
y_A	519202,94
y_B	514801,53
y_C	513935,02

Procedure:

1. In triangle *A, B, PK-77* Cartesian coordinates of point *PK-77* are calculated:

$$x_{PK-77} = \frac{x_A \operatorname{ctg} \beta_2 + x_B \operatorname{ctg} \beta_1 - y_A + y_B}{\operatorname{ctg} \beta_1 + \operatorname{ctg} \beta_2} = 6085048{,}34 \text{ m.} \quad 6.29.$$

$$y_{PK-77} = \frac{y_A \operatorname{ctg} \beta_2 + y_B \operatorname{ctg} \beta_1 + x_A - x_B}{\operatorname{ctg} \beta_1 + \operatorname{ctg} \beta_2} = 517224{,}35 \text{m.} \quad 6.30.$$

2. In triangle *B, C, PK-77* Cartesian coordinates of point *PK-77* are calculated:

$$x_{PK-77} = \frac{x_B \operatorname{ctg} \beta_4 + x_C \operatorname{ctg} \beta_3 - y_B + y_C}{\operatorname{ctg} \beta_3 + \operatorname{ctg} \beta_4} = 6085048{,}38 \text{m.} \quad 6.31.$$

$$y_{PK-77} = \frac{y_B \operatorname{ctg} \beta_4 + y_C \operatorname{ctg} \beta_3 + x_B - x_C}{\operatorname{ctg} \beta_3 + \operatorname{ctg} \beta_4} = 517224{,}48 \text{m.} \quad 6.32.$$

3. The values of calculated Cartesian coordinates of point *PK-77* differ by less than 50 cm, therefore average coordinates of point *PK-77* are calculated:

$$x_{\text{PK-77 vid.}} = 6085048{,}36\,\text{m.} \quad (6.33.)$$

$$y_{\text{PK-77 vid.}} = 517224{,}42\,\text{m.} \quad (6.34.)$$

QUESTIONS TO REPEAT:

- What is the essence of coordination of ground points?
- Describe the essence of direct angular intersection?
- Describe the essence of inverse angular intersection?
- What methods of point coordination do you know?
- What is the difference between direct and inverse direction angle?
- Describe the essence of single and multiple angular intersection.

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2	2012	Alexander, Ross, CLARKE. *Geodesy*. ISBN 978-1290098762. 378 p.*	HardPress Publishing	√		√
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3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√
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Prepared by: assistant Vincas Zakarauskas

Educational Institution: **Kauno Kolegija/ University of Applied Sciences**

Study Programme: **Real Estate Measurement Engineering**

Subject: **Geodesy**

PRACTICAL WORK NO. 7

TOPIC: MATHEMATICAL TREATMENT OF EQUAL AND UNEQUAL PRECISION SURVEY RESULTS OF ONE DEMENSION

1. The Aim of the Practical Work: to apply theoretical skills for mathematical treatment of equal and unequal precision distance measurement results and evaluation of precision of the measurements.

2. The Objectives of the Practical Work: to select minimum length value of the line, to calculate the differences between single measurement results and values close to the arithmetic mean, the arithmetic mean, rounding error, deviation of measurement results from the arithmetic mean, to check the calculation of the arithmetic mean, of squared sum of deviations from the arithmetic mean, to calculate mean squared error of one measurement, mean squared error of weight unit, mean squared error of mean squared error of one measurement, mean squared error of mean squared error of weight unit, mean squared error of the arithmetic mean, the reliability of the mean squared error of the arithmetic mean, to determine the tolerances of measurement precision with 95 % and 99,73 % precision probability, to determine relative error of line measurement results.

3. The Innovative Methods Applied in the Practical Work: team learning, discussions.

4. The Assessment of the Practical Work:

The highest level of the achievement of objectives		The medium level of the achievement of objectives		The minimum level of the achievement of objectives		Not achieved objectives			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
The most reliable value and deviations from arithmetic mean are calculated, sum of deviations from the arithmetic mean is verified, squared mean error of one measurement, squared mean error of squared mean error of one measurement, squared mean error of squared mean		The most reliable value and deviations from arithmetic mean are calculated, sum of deviations from the arithmetic mean is verified, squared mean error of one measurement, squared mean error of squared mean error of one measurement, squared mean error of squared mean error of		The most reliable value and deviations from arithmetic mean are calculated, sum of deviations from the arithmetic mean is verified, squared mean error of one measurement, squared mean error of squared mean error of one measurement, squared mean error of squared mean		The calculations are wrong.			

error of weight unit, squared mean error of arithmetic mean and squared mean error of squared mean error of arithmetic mean are calculated, confidence intervals of measured values are calculated, relative error of line measurement results is determined.	weight unit, squared mean error of arithmetic mean and squared mean error of squared mean error of arithmetic mean are calculated, confidence intervals of measured values are not calculated, relative error of line measurement results is not determined.	error of weight unit, squared mean error of arithmetic mean and squared mean error of squared mean error of arithmetic mean are calculated. The calculations have errors. Confidence intervals of measured values are not calculated, but are determined, relative error of line measurement results is not determined.	

MATHEMATICAL TREATMENT OF EQUAL PRECISION SURVEY RESULTS OF ONE DIMENSION

10 measurement series have been performed during determination of the length of datum line. Each series includes n measurements of the datum line. Arithmetic means of the datum line are calculated according to each measurement series. It is required to determine the most reliable value of the datum line and evaluate the precision of measurement.

Procedure:

1. To calculate the most reliable value – arithmetic mean.
2. To calculate deviations from arithmetic mean and verify the deviation from the sum of arithmetic mean.
3. To calculate squared mean error of one measurement.
4. To calculate squared mean error of squared mean value of one measurement.
5. To calculate squared mean error of arithmetic mean.
6. To calculate squared mean error of squared mean error of arithmetic mean.
7. To calculate confidence intervals of measured values.
8. To determine relative error of line measurement results.

The treatment of measurement results of the datum line are provided in table 7.1.

Table 7.1.

Datum line measurement results treatment

Lines	**Measurement results x_i (m)**	ε_i **(mm)**	ε^2_i **(mm²)**	ν_i **(mm)**	ν_i^2 **(mm²)**

1	107.222	3	9	-11	121
2	107.222	3	9	-11	121
3	107.242	23	529	+9	81
4	107.249	30	900	+16	256
5	**107.219**	0	0	-14	196
6	107.230	11	121	-3	9
7	107.229	10	100	-4	16
8	107.227	8	64	-6	36
9	107.245	26	676	+12	144
10	107.247	28	784	+14	196
		$\Sigma = 142$	$\Sigma = 3192$	$\Sigma = 2$	$\Sigma = 1176$

1. According to measurement results the minimum line length value of 107,219 m is taken. It will be approximate value for arithmetic mean - $\bar{x}'$.

2. The differences between single measurement results are measured and the values close to arithmetic mean: $\varepsilon_i = x_i - \bar{x}' = 107{,}222 - 107{,}219 = 0{,}003 \text{ m} = 3 \text{ mm}$.

3. Arithmetic mean is calculated:

$$\bar{x} = \bar{x}' + \frac{\sum_{i=1}^{10} \varepsilon_i}{n} = 107{,}219 + \frac{142}{10} = 107{,}2332 \approx 107{,}233 \text{ m.}$$

4. Rounding error is calculated:

$$\varphi = \bar{x} - \bar{x}_{apv.} = 107{,}2332 - 107{,}233 = +\,0{,}0002 \text{ m} = +\,0{,}2 \text{ mm.}$$

5. Measurement result deviations from arithmetic mean *v* are calculated:

$$v_1 = x_1 - \bar{x} = 107{,}222 - 107{,}233 = -\,0{,}011 \text{ m} = -11 \text{ mm}.$$

6. Calculation of the arithmetic mean is checked:

$$\sum_{i=1}^{10} \mathrm{v_i} = n \cdot \varphi = 10 \cdot 0{,}2 \text{ mm} = 2 \text{ mm.}$$

7. Calculation of sum of squared deviations from arithmetic mean is checked:

$$\sum_{i=1}^{10} \nu_i^{\,2} = \sum_{i=1}^{10} \varepsilon_i^{\,2} - \frac{\sum_{i=1}^{10} \varepsilon_i^{\,2}}{n} = 3192 - \frac{142^2}{10} = 3192 - 2016{,}4 = 1175{,}6 = 1176 \text{ mm}^2.$$

8. Squared mean error of one measurement is calculated:

$$m = \sqrt{\frac{\sum_{i=1}^{10} \nu_i^{\,2}}{n-1}} = \sqrt{\frac{1176}{10-1}} = 11{,}43 \text{ mm}.$$

9. Squared mean error of squared mean error of one measurement is calculated:

$$m_m = \frac{m}{\sqrt{2(n-1)}} = \frac{11{,}43}{\sqrt{2 \cdot (10-1)}} = 2{,}69 \text{ mm}.$$

10. Squared mean error of arithmetic mean is calculated:

$$M = \frac{m}{\sqrt{n}} = \frac{11{,}43}{\sqrt{10}} = 3{,}61 \text{ mm}.$$

11. Reliability of squared mean error of arithmetic mean is calculated:

$$m_M = \frac{m}{\sqrt{2 \cdot n}} = \frac{11{,}43}{\sqrt{2 \cdot 10}} = 0{,}81 \text{ mm}.$$

12. Measurement precision tolerances are calculated:

12.1. Confidence interval for measured distance with 95 % reliability is calculated:

$$P(\bar{x} - t_\alpha M \leq \bar{x} \leq \bar{x} + t_\alpha M) P_\alpha$$

$$P(107{,}233 \text{ m} - 2{,}145 \cdot 3{,}61 \text{ mm} < 107{,}233 \text{ m} < 107{,}233 \text{ m} + 2{,}145 \cdot 3{,}61 \text{ mm}) = P_{95\%}.$$

$$P(107{,}225 \text{ m} < 107{,}233 \text{ m} < 107{,}241 \text{ m}) = P_{95\%}.$$

12.2. Confidence interval for measured distance with 99,73 % reliability is calculated:

$$P(\bar{x} - t_{\alpha} M \leq \bar{x} \leq \bar{x} + t_{\alpha} M) P_{\alpha}$$

$$P(107{,}233 \text{ m} - 4{,}09 \cdot 3{,}61 \text{ mm} < 107{,}233 \text{ m} < 107{,}233 \text{ m} + 4{,}09 \cdot 3{,}61 \text{ mm}) = P_{99{,}73\%}.$$

$$P(107{,}218 \text{ m} < 107{,}233 \text{ m} < 107{,}248 \text{ m}) = P_{99{,}73\%}.$$

13. Relative error of line measurement results is determined:

$$\frac{1}{N} = \frac{m}{\bar{x}}; \quad \frac{1}{N} = \frac{11{,}43 \text{ mm}}{107{,}233 \text{ m}} = \frac{0{,}01143 \text{ m}}{107{,}233 \text{ m}} = \frac{1}{9400}.$$

MATHEMATICAL TREATMENT OF EQUAL PRECISION SURVEY RESULTS OF ONE DIMENSION

Procedure:

1. To select minimum line length value.
2. To calculated differences between single measurement results and the values close to arithmetic mean.
3. To calculate the arithmetic mean.
4. To calculate rounding error.
5. To calculate deviations of measurement results from arithmetic mean.
6. To check the calculation of arithmetic mean.
7. To check the calculation of sum of squared deviations from arithmetic mean.
8. To calculate squared mean error of weight unit.
9. To calculate squared mean error of squared mean error of weight unit.
10. To calculate squared mean error of gross arithmetic mean.
11. To calculate the reliability of squared mean error of gross arithmetic mean.
12. To calculate measurement precision tolerance.

13. To determine relative error of line measurement results.

The treatment of measurement results of the datum line is provided in table 7.2.

Table 7.2.

Datum lie measurement results treatments

Lines	**Measurement results** x_i **(m)**	**Weight** p	ε_i **(mm)**	$\varepsilon_i \cdot p_i$	$\varepsilon^2_i \cdot p_i$	v_i **(mm)**	$v_i \cdot p_i$	$v^2_i \cdot p_i$
1	657,988	6	11	66	726	+6	36	216
2	657,979	8	2	16	32	-3	-24	72
3	657,977	14	0	0	0	-5	-70	350
4	657,981	10	4	40	160	-1	-10	10
5	657,986	12	9	108	972	+4	48	192
6	657,980	8	3	24	72	-2	-16	32
7	657,981	4	4	16	64	-1	-4	4
8	657,987	6	10	60	600	+5	30	150
9	657,985	8	8	64	512	+3	24	72
10	657,980	12	3	36	108	-2	-24	48
		Σ = 88	**Σ = 54**	**Σ = 430**	**Σ = 3246**	**Σ = +4**	**Σ = -10**	**Σ = 1146**

1. According to measurement results the minimum line length value of 657,977 m is taken. It will be approximate value for arithmetic mean - $\bar{x}'$.

2. The differences between single measurement results are measured and the values close to arithmetic mean: $\varepsilon_i = x_i - \bar{x}' = 657{,}988 - 657{,}977 = 0{,}011\,\text{m} = 11\,\text{mm}$.

3. Arithmetic mean is calculated:

$$\bar{x} = \bar{x}' + \frac{\sum_{i=1}^{10} \varepsilon_i \cdot p_i}{\sum_{i=1}^{10} p_i} = 657{,}977 + \frac{430}{88} \cdot 1000 = 657{,}9819\text{ m} \approx 657{,}982\text{ m}.$$

4. Rounding error is calculated:

$$\varphi = \bar{x} - \bar{x}_{apv.} = 657{,}98189 - 657{,}982 = -\,0{,}00011\,\text{m} = -\,0{,}11\,\text{mm}.$$

5. Measurement result deviations from arithmetic mean v are calculated:

$$v_1 = x_1 - \bar{x} = 657{,}988 - 657{,}982 = -0{,}011\,\text{m} = -11\,\text{mm}.$$

6. Calculation of the arithmetic mean is checked:

$$\sum_{i=1}^{10} v_i p_i = \varphi \sum_{i=1}^{10} p_i = -0{,}11 \cdot 88 = -9{,}68 \approx -10\ \text{mm}.$$

7. Calculation of sum of squared deviations from arithmetic mean is checked:

$$\sum_{i=1}^{10} \nu_i^{2} \cdot p_i = \sum_{i=1}^{10} \varepsilon_i^{2} \cdot p_i - \frac{\left(\sum_{i=1}^{10} \varepsilon_i \cdot p_i\right)^2}{n} = 3246 - \frac{430^2}{10} = 3246 - 2101{,}1 = 1144{,}9\ \text{mm}^2.$$

8. Squared mean error of weight unit is calculated:

$$\mu = \sqrt{\frac{\sum_{i=1}^{10} \nu_i^{2}\ p_i}{n-1}} = \sqrt{\frac{1146}{10-1}} = 11{,}28\ \text{mm}.$$

9. Squared mean error of squared mean error of weight unit is calculated:

$$m_\mu = \frac{\mu}{\sqrt{2(n-1)}} = \frac{11{,}28}{\sqrt{2\,(10-1)}} = 1{,}41\,\text{mm}.$$

10. Squared mean error of gross arithmetic mean is calculated:

$$M = \frac{\mu}{\sqrt{\sum_{i=1}^{10} p_i}} = \frac{11{,}28}{\sqrt{88}} = 1{,}20\ \text{mm}.$$

11. The reliability of squared mean error of gross arithmetic mean is calculated:

$$m_M = \frac{M}{\sqrt{2 \cdot n}} = \frac{1,20}{\sqrt{2 \cdot 10}} = 0,27 \text{ mm}.$$

12. Measurement precision tolerances are calculated:

12.1. Confidence interval for measured distance with 95 % reliability is calculated:

$$P(\bar{x} - t_\alpha M \le \bar{x} \le \bar{x} + t_\alpha M) P_\alpha$$

$$P(657{,}982 \text{ m} - 2{,}145 \cdot 1{,}20 \text{ mm} < 657{,}982 \text{ m} < 657{,}982 \text{ m} + 2{,}145 \cdot 1{,}20 \text{ mm}) = P_{95\%}.$$

$$P(657{,}979 \text{ m} < 657{,}982 \text{ m} < 657{,}984 \text{ m}) = P_{95\%}.$$

12.2. Confidence interval for measured distance with 99,73 % reliability is calculated:

$$P(\bar{x} - t_\alpha M \le \bar{x} \le \bar{x} + t_\alpha M) P_\alpha$$

$$P(657{,}982 \text{ m} - 4{,}09 \cdot 1{,}20 \text{ mm} < 657{,}982 \text{ m} < 657{,}982 \text{ m} + 4{,}09 \cdot 1{,}20 \text{ mm}) = P_{99,73\%}.$$

$$P(657{,}977 \text{ m} < 657{,}982 \text{ m} < 657{,}987 \text{ m}) = P_{99,73\%}.$$

13. Relative error of line measurement results is determined:

$$\frac{1}{N} = \frac{M}{\bar{x}}; \qquad \frac{1}{N} = \frac{1{,}20 \text{ mm}}{657{,}982 \text{ m}} = \frac{0{,}0012 \text{ m}}{657{,}982 \text{ m}} = \frac{1}{550000}.$$

QUESTIONS TO REPEAT:

- How is the measurement quality described?
- What requirements must meet the same measurement conditions?
- How are deviations of measurement results from arithmetic mean calculated?
- How is the squared mean error of one measurement calculated?

- How is the reliability of squared mean error of arithmetic mean calculated?
- What is tolerance?

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1		*Geodezija ir kartografija.* ISSN 1392-1541	Technika	√		√
2		*Geodesy and cartography.* ISSN 2029 – 6991*	Vilniaus Gedimino technikos universitetas, geodezijos institutas	√		√
3		*Matavimų inžinerija ir GIS.* ISSN 2029-5790	Kauno kolegija	√		√

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3		http://www.gsb.lt				

* references for international students

Prepared by: assistant Vincas Zakarauskas

KAUNO KOLEGIJA

UNIVERSITY OF APPLIED SCIENCES

FACULTY OF LANDSCAPING

DEPARTMENT OF GEODESY

EVALUATED:__________________________

Date: __________________________2012

Teacher

______________________Vincas Zakarauskas

(signature)

Variant No._____

____________group student____

(name, surname, signature)

GEODESY
1 mid-term test

Note: The answers must be concise, clearly worded. Writing must be readable. Every question is valued by number of points indicated next to the question.

1. What is the precision of determination of horizontal position of a point when measuring by Real Time Kinematic method using LITPOS *and LEICA SMART NET LT* networks of permanent reference GNSS stations*?* (0,5 point)

2. Please, characterize *GLONASS* navigation satellite system? (0,5 point)

3. What is ephemeris? (0,5 point)

4. What does the GPS space segment consist of? (0,5 point)

5. What are the functions of GPS control segment? (1 point)

6. What GPS geodetic measurement methods do you know? (1 point)

7. Please, characterize *GALILEO* navigation system? (0,5 point)

8. Please, characterize the essence of the Static GPS measurement method? (1 point)

9. Please, characterize the essence of the Real Time Kinematic GPS measurement method? (1 point)

10. What GPS measurable values do you know? (0,5 point)

11. What is the altitude of GPS *NAVSTAR* satellites and how many orbits does it consist of? (0,5 point)

12. What is the purpose of LITPOS networks of permanent reference GNSS stations? (0,5 point)

13. What is the environmental effect on GPS measurements? What environmental effect factors do you know? (1 point)

14. What are the main nodes and elements of GPS satellite? (1 point)

15. What is the angle of satellite inclination above the horizon set for in GPS device? What angle value is set? (0,5 point)

UNIVERSITY OF APPLIED SCIENCES

FACULTY OF LANDSCAPING

DEPARTMENT OF GEODESY

EVALUATED:_________________________

Date: _________________________2012

Teacher

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GEODESY

2 mid-term test

Task. Three points with known coordinates are given. The angles at points *A*, *B*, *C* are measured. Find the coordinates of point *PK-77*.

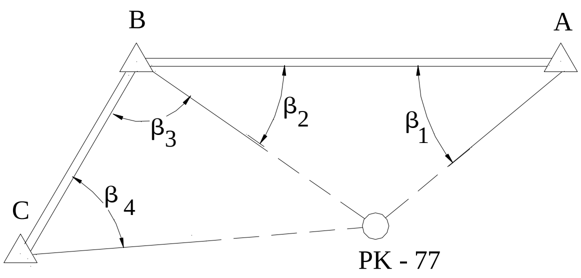

Fig. 2.1. Scheme of direct angular intersection

Table 2.1

Measurement data

Points	Angles
$ß_1$	33°32'18"
$ß_2$	26°02'22"
$ß_3$	82°09'45"
$ß_4$	57°23'30"

Table 2.2.

Point coordinates

Points	Coordinates, m
x_A	5086116,04
x_B	5086517,83
x_C	5084516,92
y_A	419202,94
y_B	414801,53
y_C	413935,02

1. Find plane rectangular coordinates of point *PK-77* of triangle *A, B, PK-77*:

$$x_{\text{PK}-77} = \frac{x_{\text{A}}\text{ctg}\,\beta_2 + x_{\text{B}}\text{ctg}\,\beta_1 - y_{\text{A}} + y_{\text{B}}}{\text{ctg}\,\beta_1 + \text{ctg}\,\beta_2} = \qquad 2.1.$$

$$y_{\text{PK}-77} = \frac{y_{\text{A}}\text{ctg}\,\beta_2 + y_{\text{B}}\text{ctg}\,\beta_1 + x_{\text{A}} - x_{\text{B}}}{\text{ctg}\,\beta_1 + \text{ctg}\,\beta_2} = \qquad 2.2.$$

2. Check plane rectangular coordinates of point *PK-77* of triangle *B, C, PK-77*:

$$x_{\text{PK}-77} = \frac{x_{\text{B}}\text{ctg}\,\beta_4 + x_{\text{C}}\text{ctg}\,\beta_3 - y_{\text{B}} + y_{\text{C}}}{\text{ctg}\,\beta_3 + \text{ctg}\,\beta_4} = \qquad 2.3.$$

$$y_{\text{PK}-77} = \frac{y_{\text{B}}\text{ctg}\,\beta_4 + y_{\text{C}}\text{ctg}\,\beta_3 + x_{\text{B}} - x_{\text{C}}}{\text{ctg}\,\beta_3 + \text{ctg}\,\beta_4} = \qquad 2.4.$$

3. Evaluate the reliability of found coordinates for point *PK-77*; they may differ by 50 cm

4. Find mean coordinates of point *PP-77*:

$$\text{x}_{PK-77\;mean} = \qquad 2.5.$$

$$\text{y}_{PK-77\;mean} = \qquad 2.6.$$

Sequence:

1. Find coordinates of *PP-77* of triangle *A, B, PP-77*.
2. Check the calculation of point *PP-77* coordinates of triangle *C, B, PP-77*.
3. Evaluate the reliability of found coordinates; they may differ by 50 cm.
4. Find mean coordinates of point *PP-77*.

Assessment of Mid-term Test:

The highest level of the achievement of objectives		**The medium level of the achievement of objectives**		**The minimum level of the achievement of objectives**		**Not achieved objectives**			
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Coordinates of point *PP-77* of triangle *A, B, PP-77* are found , the calculation of point *PP-77* coordinates of triangle *C, B, PP-77* is checked, the reliability of found coordinates is evaluated, mean coordinates of point *PP-77* are calculated.		Coordinates of point *PP-77* of triangle *A, B, PP-77* are found, the calculation of point *PP-77* coordinates of triangle *C, B, PP-77* is checked, the reliability of found coordinates is not evaluated, mean coordinates of point *PP-77* are not calculated or calculations are wrong.		Coordinates of point *PP-77* of triangle *A, B, PP-77* are found, the calculation of point *PP-77* coordinates of triangle *C, B, PP-77* is not checked, the reliability of found coordinates is not evaluated, mean coordinates of point *PP-77* are not calculated or calculations are wrong.		Coordinates of point *PP-77* of triangle *A, B, PP-77* are not found or calculations are wrong, the calculation of point *PP-77* coordinates of triangle *C, B, PP-77* is not checked, the reliability of found coordinates is not evaluated, mean coordinates of point *PP-77* are not calculated or calculations are wrong.			

KAUNO KOLEGIJA

UNIVERSITY OF APPLIED SCIENCES
FACULTY OF LANDSCAPING
DEPARTMENT OF GEODESY

APPROVED BY
The Head of the Department of Geodesy
____
Birute Nenortaite

Form of Studies:	**Full-time studies**
Study Programme:	**Real Estate Measurement Engineering**
Subject:	**Geodesy**
Group:	**NT 1**
Semester:	**Autumn semester**
Teacher:	**Vincas Zakarauskas**
Test Form:	**Examination**
Examination Date:	**January 2013**

Assessment of the achievement level of the subject outcomes according to the task:

1. To select and check, adjust precise leveling devices.
2. To carry out precision leveling applying different methods.
3. To evaluate leveling results and their accuracy.
4. To select and evaluate geodetic devices for formation of geodetic networks.
5. To design and develop the detailed background for a plan.
6. To select and perform the measurements using electronic distance and angle measuring devices.
7. To know what is the Global Positioning System, its application possibilities dealing with various geodetic tasks.
8. To link geodetic measurements to the sections of national geodetic network.
9. To analyze formation methods of the Lithuanian National Geodetic Network.
10. To analyze and adapt point coordination methods.
11. To plan, develop and evaluate the measurement according to GKTR (Technical Regulation of Geodetic Cartography) requirements.

Learning outcomes: No. 1, 2, 3 are the constituents of study subject outcomes No. 1.1., 1.2., 2.1., 3.1., 3.2., 3.3.

Teacher ___________________ Vincas Zakarauskas
(signature) (name, surname)

UNIVERSITY OF APPLIED SCIENCES
FACULTY OF LANDSCAPING

DEPARTMENT OF GEODESY

EVALUATED:________________________

Date: ________________________2012

Teacher ____________________Vincas Zakarauskas
(signature)

Variant No.____

________group student____
(name, surname, signature)

GEODESY
Examination (part I– theoretical questions)

Note: The answers must be concise, clearly worded. Writing must be readable. Every question is valued by number of points indicated next to the question.

1. When and who by was the first precision leveling network of Lithuania established? (0, 1 point)

2. What is leveling? (0,1 point)

3. What is the precision of determination of horizontal position of a point when measuring by Real Time Kinematic method using LITPOS *and LEICA SMART NET LT* networks of permanent reference GNSS stations? (0,1 point)

4. Please, characterize *GLONASS* navigation satellite system? (0,3 point)

5. At what depth are the benchmarks of the Lithuanian National Vertical First Order Network dug in? (0,1 point)

6. What is the average distance for installation of reference benchmarks and wall benchmarks creating the Lithuanian National Vertical First Order Network? (0,1 point)

7. When and who did create the first in the world digital level? (0,1 point)

8. What are the advantages of leveling with precie digital levels? (0,2 point)

9. What does the accuracy of measurements by leveling with digital levels depend on? (0,3 point)

10. What image processing methods applied in modern digital levels do you know? (0,1 point)

11. What is ephemeris? (0,1 point)

12. What does the GPS space segment consist of? (0,3 point)

13. What are the functions of GPS control segment? (0,3 point)

14. What GPS geodetic measurement methods do you know? (0,3 point)

15. Please, characterize *GALILEO* navigation system? (0,3 point)

16. Please, characterize the essence of the Static GPS measurement method? (0,4 point)

17. Please, characterize the essence of the Real Time Kinematic GPS measurement method? (0,4 point)

18. What GPS measurable values do you know? (0,1 point)

19. What is the altitude of GPS *NAVSTAR* satellites and how many orbits does it consist of? (0,1 point)

20. What is the purpose of network of permanent reference GNSS stations LITPOS? (0,3 point)

21. How was the network of permanent reference GNSS stations LITPOS created? (0,3 point)

22. How were the coordinates of points of the network of permanent reference GNSS stations LITPOS determined?
(0,1 point)

23. What is the purpose of electronic tachometer? (0,1 point)

24. What is the commonly used method for measuring of picket points with electronic tachometer? (0,1 point)

25. Characterize the code method of limb spreading of electronic tachometer? (0,1 point)

26. Characterize the positioning method of limb spreading of electronic tachometer? (0,1 point)

27. Characterize the incremental method of limb spreading of electronic tachometer? (0,1 point)

UNIVERSITY OF APPLIED SCIENCES

FACULTY OF LANDSCAPING

DEPARTMENT OF GEODESY

EVALUATED:_________________________

Date: _________________________2012

Teacher _____________________Vincas Zakarauskas

(signature)

Variant No.____

________group student____

(name, surname, signature)

GEODESY

Examination (part I – theoretical questions)

Note The answers must be concise, clearly worded. Writing must be readable. Every question is valued by number of points indicated next to the question.

1. Please, characterize *GALILEO* navigation system? (0,3 point)

2. Please, characterize the essence of the Static GPS measurement method? (0,4 point)

3. Please, characterize the essence of the Real Time Kinematic GPS measurement method? (0,3 point)

4. What GPS measurable values do you know? (0,4 point)

5. What is the altitude of GPS *NAVSTAR* satellites and how many orbits does it consist of? (0,1 point)

6. What is the purpose of the network of permanent reference GNSS stations LITPOS? (0,2 point)

7. How is the network of permanent reference GNSS stations LITPOS made? (0,2 point)

8. How were the coordinates of points of the network of permanent reference GNSS stations LITPOS determined?
(0,1 point)

9. What is electronic tachometer? (0,1 point)

10. What is the principle of measurement of picket points with electronic tachometer? (0,1 point)

11. Characterize the code method of limb spreading of electronic tachometer? (0,1 point)

12. Characterize the positioning method of limb spreading of electronic tachometer? (0,1 point)

13. Characterize the incremental method of limb spreading of electronic tachometer? (0,1 point)

14. When and who by was the first precision leveling network of Lithuania established? (0,1 point)

15. What is leveling? (0,1 point)

16. What is the precision of determination of horizontal position of a point when measuring by Real Time Kinematic method using LITPOS *and LEICA SMART NET LT* networks of permanent reference GNSS stations? (0,1 point)

17. Please, characterize *GLONASS* navigation satellite system? (0,3 point)

18. At what depth are the ground control points of the Lithuanian National Vertical First Order Network dug in? (0,1 point)

19. What is the average distance for installation of reference benchmarks and wall benchmarks creating the Lithuanian National Vertical First Order Network? (0,1 point)

20. When and who did create the first in the world digital level? (0,1 point)

21. What are the advantages of leveling with precise digital levels? (0,2 point)

22. What does the accuracy of measurements by leveling with digital levels depend on? (0,2 point)

23. What image processing methods applied in modern digital levels do you know? (0,2 point)

24. What is ephemeris? (0,1 point)

25. What does the GPS space segment consist of? (0,3 point)

26. What are the functions of GPS control segment? (0,3 point)

27. What GPS geodetic survey methods do you know? (0,3 point)

Practical task No.1. Single direct angular intersection. Coordinates of points T_1, T_2 *and* T_3 are given, and angles β_n are measured. Find the coordinates of point *PK-1968* (Fig.1.).

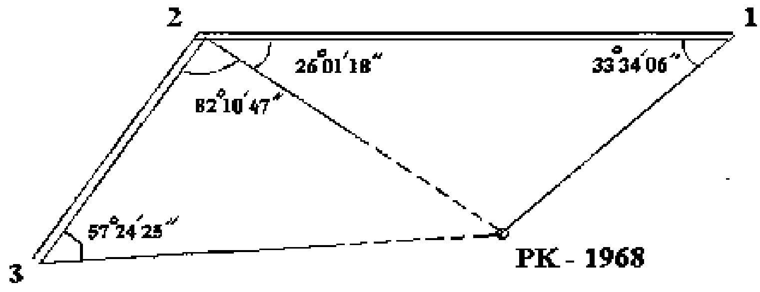

Fig. 1. Scheme of direct angular intersection

Points	*x*, m	*y*, m
T_1	86 000,9	19 190,9
T_2	86 517,8	14 801,5
T_3	84 540,3	13 882,9

Calculations:

$$x_p = \frac{x_{T_1} ctg\beta_2 + x_{T_2} ctg\beta_1 - y_{T_1} + y_{T_2}}{ctg\beta_1 + ctg\beta_2}$$

$$y_p = \frac{y_{T_1} ctg\beta_2 + y_{T_2} ctg\beta_1 + x_{T_1} - x_{T_2}}{ctg\beta_1 + ctg\beta_2}$$

Practical task No. 2. To perform precision leveling between two points specified by the teacher applying BFFB method. Use precise digital level *Topcon DL - 102 C* or similar.

To determine the following parameters:

1. Mean value of backsight readings.
2. Error in differences = (*Backsight* 1 – *Foresight* 1) – (*Backsight* 2 – *Foresight* 2).
3. Distance to the rod backsight.
4. n –rod scale.
5. σ – standard deviation.
6. d = Final distance backsight – Final distance foresight.
7. Σ = Final distance backsight + Final distance foresight.
8. Altitude change between the backsight 2 and foresight 2 measurements.
9. Altitude change on the station.
10. Benchmark (point) altitude.
11. Backsight point number.

Practical task No.3. Perform topographical works using electronic tachometer. The teacher specifies four picket points. It is required to carry out geodetic measurements of these pickets and to check the obtained results:

1. Horizontal angles.
2. Vertical angles and calculated inclination angles.
3. Measured distances on the ground surface.
4. Horizontal projections of measured distances.
5. Differences in heights to the picket points.
6. Coordinates of picket points.
7. Altitudes of picket points.

General assessment of the results of the examination

The teacher organizes, conducts and evaluates the results of examination.

Examination results are marked on a ten-point scale.

Assessment of the results of examination is performed following the achievement levels of subject outcomes defined as follows:

the highest level of achievement of the objectives (9-10 points): all tasks are completed; answers are acceptable, comprehensive and reasonable; original or several acceptable options of solution of raised problems are provided and the optimal option is reasonably selected; various and adequate theoretical models and analyses are applied to deal with the tasks, and the obtained results are compared; comprehensive theoretical knowledge is demonstrated according to the objectives specified in task appendices;

the medium level of achievement of the objectives (7-8 points): more than two-thirds of all tasks are completed; the answers to questions and problem solutions are acceptable and reasonable; adequate theoretical models and analyses are applied to deal with the tasks; good theoretical knowledge is demonstrated according to the objectives specified in task appendices;

the minimum compulsory level of achievement of the objectives (5-6 points): more than half of all tasks is completed; the answers are acceptable in general; problems are solved in general; acceptable theoretical models and analyses are applied to deal with the tasks; minimum of necessary theoretical knowledge is demonstrated according to the objectives specified in task appendices.

Theoretical task takes up 50% of the exam value. Every question is valued by a point indicated next to it. Practical task takes up 50% of the exam value: the first practical task – 20%, the second practical task – 30%, the third practical task – 50% of the total value of the practical test.

The task is marked on 10-point scale. $P = 0,2 \times 1PU + 0,3 \times 2PU + 0,5 \times 3PU$

here: 1PU; 2PU, 3PU – practical tasks

Assessment criteria of the practical task No. 1:

The highest level of the achievement of objectives		The medium level of the achievement of objectives		The minimum level of the achievement of objectives		Not achieved objectives			
10	9	8	7	6	5	4	3	2	1
x or y coordinates of point *PK-1968* are calculated, the calculation of coordinates is checked, change of x and y coordinates of the calculated point does not exceed 0,3 m. The task is completely performed.		x or y coordinates of point *PK-1968* are calculated for two triangles, without checking the coordinated points. Change of x and y coordinates of the calculated point does not exceed 0,3 m. x or y coordinates of point *PK-1968* are calculated for one triangle, but check calculation was not performed. The calculation of x or y coordinates of point *PK-1968* is wrong, check calculation is not complete.		x or y coordinates of point *PK-1968* are calculated for two triangles performing the check of coordinated points. Change of x and y coordinates of the calculated point does not exceed 0,3 m. x or y coordinates of point *PK-1968* are not calculated. The calculation is not checked.		x or y coordinated of point *PK-1968* are calculated for one triangle only, check calculation for other triangle is not performed. Secondary calculation only are carried out. Calculations of coordinates of point *PK-1968* were not carried out or they are wrong, without check calculation.			

Assessment criteria of the practical task No. 2:

The highest level of the achievement of objectives		The medium level of the achievement of objectives		The minimum level of the achievement of objectives		Not achieved objectives			
10	9	8	7	6	5	4	3	2	1

Average value of backsight readings is determined. Error in differences = (Backsight 1 – Foresight 1) – (Backsight 2 – Foresight 2) was determined. Backsight distance to the rod was determined. The total number of measurements was determined, standard deviation. Distance to the place of installation of the level (in meters) was determined. Leveling length from reference benchmark was determined. Change of heights in difference backsight 2 and foresight 2 was determined; Change of heights at the station was determined. The altitude of benchmark (point) was determined. Numbers of points (benchmarks) were determined. The task is completely performed.	The following measurements can be carried out in the course of measurements: determination of the average value of backsight readings. Determination of the error in differences = (Backsight 1 – Foresight 1) – (Backsight 2 – Foresight 2). Determination of backsight distance to the rod. Determination of the total number of measurements, standard deviation. Distance to the place of installation of the level (in meters) was determined. Leveling length from reference benchmark was determined. Determination of the change of heights in difference backsight 2 and foresight 2; Change of heights at the station was determined. The altitude of benchmark (point) was determined. Numbers of points (benchmarks) were determined. Approximately 70-80 % of the task were performed.	The following measurements may be carried out in the can of measurements: determination of the average value of backsight readings. Determination of the error in differences = (Backsight 1 – Foresight 1) – (Backsight 2 – Foresight 2). Determination of the backsight distance to the rod. Determination of the total number of measurements, standard deviation. Distance to the place of installation of the level (in meters) was determined. Leveling length from reference benchmark was determined. Determination of the change of heights in difference backsight 2 and foresight 2; Change of heights at the station was determined. The altitude of benchmark (point) was determined. Numbers of points (benchmarks) were determined. Approximately 50-70 % of the task were performed.	Some measurements can be carried out in the course of the measurements, non-systematic measurements: Other secondary tasks performed only. Less than 50 % of the task were performed.

Assessment criteria of the practical task No. 3:

The highest level of the achievement of objectives		The medium level of the achievement of objectives		The minimum level of the achievement of objectives		Not achieved objectives			
10	9	8	7	6	5	4	3	2	1

Measurement of horizontal angles was performed. Measurement of vertical angles was performed and vertical angles were calculated. Distances were measured. Line slope lengths and horizontal projections were determined. Measurements of changes of height to pickets. Coordinates of picket points were determined. Picket altitudes were determined. The task is completely performed.	The following measurements can be carried out in the course of measurements: Measurement of horizontal angles was performed. Measurement of vertical angles was performed and vertical angles were calculated. Distances were measured. Line slope lengths and horizontal projections were determined. Measurements of changes of height to pickets. Coordinates of picket points were determined. Picket altitudes were determined. Approximately 70-80 % of the task were performed.	The following measurements can be carried out in the course of measurements: Measurement of horizontal angles was performed. Measurement of vertical angles was performed and vertical angles were calculated. Distances were measured. Line slope lengths and horizontal projections were determined. Measurements of changes of height to pickets. Coordinates of picket points were determined. Picket altitudes were determined. Approximately 50 - 60 % of the task were performed.	Some measurements can be carried out in the course of the measurements, non-systematic measurements: Other secondary tasks performed only. Less than 50 % of the task were performed.

Examination assessment E = 0,5T + 0,5P

here: T– theoretical task;
P– practical task

Examination is passed if subject objectives are achieved at least to the minimum compulsory level.

The outcomes of studies are determined by the total index of assessment of student's knowledge and skills - individual cumulative index (ICI).

ICI = 0,5 E + 0,15 K + 0,15 P + 0,2 S,

here: E - examination, K – mid-term tests, P – practical works, S – individual works.

Teacher ________________ Vincas Zakarauskas

(signature)