Type of programme: full-time bachelor's degree, 7-semesters with no of hours /week and ECTS

Field of education: Geodesy and Cartography

No	Course	Plan	I l	I e	I p	I ECTS	II l	II e	II p	II ECTS	III l	III e	III p	III ECTS	IV l	IV e	IV p	IV ECTS	V l	V e	V p	V ECTS	VI l	VI e	VI p	VI ECTS	VII l	VII e	VII p	VII ECTS
	l - lecture, e - exercises, p - project, E - exam																													
— **General courses including humanities and economics, and major for the field of education**																														
1	Facultative class 1 - Humanities, economic and social and law subjects																													
1a	Facultative class 1a - Intellectual property law	15					1			1																				
1b	Facultative class 1b - Entrepreneurship	15					1			1																				
1c	Facultative class 1c - Law (civil, administrative, economic)	30																	2			2								
1d	Facultative class 1d - Humanities, economic and social (HES)	30																					2			2				
2	Foreign language (selected one) /E (B2)							4		4		4		4		4		4												
3	Sport class			2		0		2		0		2		0																
	SUM	90	0	2	0	0	2	6	0	6	0	6	0	4	0	4	0	4	2	0	0	2	2	0	0	2	0	0	0	0
— **Basic courses**																														
4	Mathematics	0																												
4a	Linear algebra in geodesy /E	45	1	2		4																								
4b	Mathematical analysis /E	120	2	2		5	2	2		4																				
4c	Probabilistic basis for adjustment of observations /E	30					1	1		3																				
4d	Differential geometry	30																												
5	Physics /E	105	2	1		4	2		2	4																				
6	Descriptive Geometry	30	1	1		3																								
7	Engineering Graphics	60	1	1		3						2		2																
8	Computer science in geodesy /E	45									1	2		3																
9	Block A - Facultative class of limited choice /E (Computer Science in Geodesy II)	45													1	2		3												
	SUM		7	7	0	19	5	3	2	11	1	4	0	5	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0
— **Profile courses**																														
10	Basics of Surveying /E	120	2	2		5	2		2	5																				
11	Detailed surveying /E	105													2		2	5	2		1	4								
12	Engineering and Industrial Geodesy /E	105																	2		2	5	2		1	3				
13	Electronic Measurement Techniques in Geodesy	30									1		1	3																
14	Geodesy /E	120									2		2	5	2	2		4												
15	Geodetic Astronomy and Geodynamics	45									2	1		3																
16	Satellite Geodesy /E	60													2	2		4												
17	Adjustment Calculus /E	75					1	1		2	1	2		3																
18	Land Information Systems	30													1	1		2												
19	Fundamentals of Photogrammetry	30													1		1	2												
20	Photogrammetric Measurement Technologies /E	75																	2		2	5	1		2					
21	Remote Sensing	45																	1	1		3	1		2					
22	Principles of Map Projections	30													1	1		2												
23	Topographic Cartography	30																	1		1	2								
24	Fundamentals of Cartographic Visualization /E	30																					1		1	3				
25	Fundamentals of Soil Science	30					1		1	2																				
26	Introduction to Earth Science and Geomorphology	30	2			3																								
27	Cadastre /E	60																	2	2		5								
28	Rural Management /E	45																					2		1	4				
29	Real Estate Management	30																									2			3
30	Basics of civil engineering	15									1			2																
31	Spatial Planning	15																	1			2								
32	Block B - Facultative class of limited choice /E (Geographic Information Systems)	45																					1		2	3				
33	Block C - Facultative class of limited choice /E (Geodetic displacement measurements)	45																					1		2	4				
34	Block D - Facultative class of limited choice (Real Estate Valuation)	15																									1			2
35	Block E - Facultative class of limited choice (Introduction to Databases)	30									1		1	3																
36	Facultative class 2																		2		2									
37	Facultative class 3																						2	2						
38	Facultative class 4																						2			3				
39	Facultative class 5																						2			3				
40	Facultative class 6																						1			2				
41	Internships (4 weeks)																													4
42	Diploma Seminar																							1		1	1			2
43	Diploma Thesis																													15
44	Field Training in Fundamentals Surveying				9 working days					4																				
45	Field Training in Geodesy and Satellite Geodesy														9 working days			4												
46	Field Training in Detailed Surveying																		8 working days			3								
47	Field Training in Engineering and Industrial Surveying																		4 working days			1								
	SUM	0	4	2	0	8	4	1	3	13	8	4	3	19	9	2	7	23	13	3	6	28	7	1	11	28	8	1	0	34
	TOTAL		11	11	0	27	11	10	5	30	9	14	3	28	10	8	7	30	15	3	6	30	9	1	11	30	8	1	0	34

Courses descriptions

General courses

1 — Civil, Administration, Business Law

The concept, systematics and sources of law, including EU law. Basic concepts of law - legal norm and its types, legal regulation and legal norm, legal relationship. Principles of civil law. The concept of subjective rights and their types. Representation and statute of limitations. Declaration of intent. Disadvantages of declarations of will. Subjects of law and objects of law. Rights in rem - division, types and features. Property and other rights in rem. Contracts as a source of obligations. The principle of freedom of contract. Ways of concluding a contract. Completing of contractual obligations. Consequences of non-performance or improper performance of the contract. The courts - their structure and scope of examined cases. Dispute settlement. Basic information on administrative law. Administrative authorities and their structure. Government and local government administration and the authorities performing tasks in the field of geodesy and cartography within its. Administrative proceedings – the rules and the course Administrative rulings. Their types and structure. Delivery in administrative proceedings. Appeals in administrative proceedings. Administrative court proceedings. Taking up and running a business. Forms of running business and limitations in undertaking and running it

Basic courses

4a — Linear Algebra in Geodesy

The course covers those aspects of linear algebra which are needed in teaching basic geodetic theories and methods. The assumed effect of the course is a good skill in the use of vector-matrix calculus in solving basic geodetic problems; a good skill in interpretation with the use of methods and concepts of linear algebra of the solution of geodetic problems, like the least-squares approximation or the network solutions. We focus attention on the application of matrix factorization methods, such as those using triangular matrices ($A=LU$, $A=LDU'$, $PA=LU$, $A=P_1L_1U_1$), those associated with matrix diagonalization associated with the eigenvalue problem ($A=S\Lambda S^{-1}$, $A=Q\Lambda Q^T$) and those following from the orthogonalization procedures ($A=QR$).

4c — Probabilistic Basis for Adjustment of Observations

The course covers fundamentals of probability theory and statistics which are needed in teaching geodetic adjustment methods. The following subjects are included in the course: 1) introduction to the theory of probability; 2) random variables with discrete and continuous dis-tribution; 3) multidimensional random variables; 4) estimation of statistical parameters – expected value, variance, standard deviation and correlation coefficient, confidence intervals of the estimated values; 5) verification of statistical hypotheses, particularly those concerning the expected value, variance, standard deviation and correlation coefficient; 6) propagation of the vector of expected values and the covariance matrix associated with transformation of the random vector.

6 — Descriptive Geometry

Lectures. Parallel projection, invariants, oblique parallel axonometric projection. Dimetry and isometries. Rectangular projection. Characteristic invariant of rectangular projection. A gage projection. Map the point, line, and plane. The slope of the line and the plane to the projector. Slope and module. Conditions for parallelism between lines and planes. Affiliation and Common. The projection plane and any plane. Perpendicularity of straight lines and planes. Curves and topographic surfaces. Slope line and sloping surface. Rectangular projections into two or more projections. Map the point, line, and plane. Affiliation and Common. Polygon and polyhedron penetration. Change of reference system (transformation). Turnover and laps. Rotary surfaces, equator and main and side meridians. Affiliation to the rotating surface. Cross-sections and penetrations of rotary surfaces. Middle projection - basic news. Vertical perspective (two convergent). Design. Drawing axonometry of polyhedra and rotary surfaces. The slope and module of the straight and the plane. Tasks for affiliation and parallelism of elements. Determination of polygon and polyhedral puncture points. The edge of planes is the penetration of polygons. Measurement tasks for applying the layout of the projecting plane and any plane. Tasks for the application of perpendicularity and plane. Solving tasks based on basic structures in rectangular projections. Plot three flips of polyhedron with hole or notch. Application in the tasks of changing the reference system (transformation).Use of rotation and system structures in flat measurement tasks. Three flips of rotating lump with notch or hole. Vertical perspective of polyhedron.

7a — Engineering Graphics

Technical drawing, rules for its implementation and applicable standards. Surveying drawing. Analog and digital form of graphic documents. Computer graphics: raster and vector forms, popular graphics formats, software used to create computer graphics. Applicable law regulations regarding maps and geodetic documents. Conventional signs used on the base map. The base map in the analog version and the numerical map. Design principles in CAD. Preparation of the project, setting the environment (units of measure, coordinates, boundaries, etc.), editing 2D graphics, cooperation with other editors (import, export), copying and printing the project.

7b	Engineering Graphics 2	Introduction to Microstation. Working with views (group management, saving, attributes). Design file configuration (colors, coordinate format, precision, locks, etc.). Introduction of basic drawing tools (lines, arcs, polygons, ellipses). Draw Precision Draw with AccuDraw and Snap Mode. Editing drawing objects (copy, rotate, scale, etc.). Measurements of drawing objects with the use of Microstation tools. Working with layers (element attributes, filters, layer manager). Text elements (creating and editing styles). Advanced techniques for modifying objects (trimming, lengthening, etc.). Working with cells (creating cells, cell libraries). Grouping of elements (chains and complex polygons, graphic groups). Reference files. Printing.
8	Computer Science in Geodesy	Programing language classification: high level, low level (machine language). The basic paradigms of programming language: imperative (procedural, object-oriented) and declarative (functional, logic). The execution methods of programming languages: compiling, interpreting. Algorithms and forms of its implementation: flowcharts, pseudo-codes, code. Basic syntax structures of programming languages on the example of Python. Selected programming environments for the Python language (Jupyter Notebook, Spyder). Type of variable (built-in variables and standard variable type in Python). Basic methods for Python variables. Conditional statements (if/elif/else) and loops (for, while). Defining functions, passing arguments to the function. File operations (reading, writing). String formatting methods (f-string, format methods). Numpy library - numerical operations, selected algorithms of numerical methods and linear algebra. Matplotlib library - graphical presentation of numerical results. Introduction to object-oriented programming: definition of object classes, rules of inheritance. Syntax errors and exception handling (try/except, raise, assert). Expressions and operators of functional paradigm (lambda, map, filter, list comprehension). Python library managers and creating programming environments (pip, env, conda).
9	Block A - Facultative class of limited choice - Computer Science in Geodesy II	Lecture: Basics of HTML (forms, controls, styles, JavaScript). Basic elements Basics of PHP (language syntax, operators, loops, arrays, passing variables between pages). Exercises: 1. Developing your own website based on the basics of HTML. 2. Development of a PHP program that uses the transfer of variables between pages.
	Profile courses	
10a	Basics of Surveying	Tasks of geodesy as a science and as a field of engineering activity. An introduction to spatial reference systems (the physical surface of the Earth, geoid, rotational ellipsoid and its projection onto a plane). Equipotential surface of the Earth's gravity as a reference surface for geodetic measurements. Geodetic measurements (their essence, systematics, tools, measurement technique and preliminary elaboration of the results). Geodetic novel: essence, definition and systematics. Horizontal angle and vertical angle and their measurement. Calculus of coordinates on a plane. Measurement errors and their classification. Elements of the theory of errors: definition of measurement, the concept of mean error and weights, mean error of the function. The essence of alignment. Alignment of the traverse and the traverse network using the approximate method. Methodology of calculating the surface area. Large-scale map (traditional and contemporary) and the process of its creation. Basics of the construction of geodetic instruments (theodolite, leveler, electronic total station). Methods of checking and rectifying instruments. Methods of geodetic measurements for the preparation of the base map. Classification of field details and technical regulations for their measurement. Designing, setting up, measuring and calculating detailed networks. The influence of the environment on the results of geodetic measurements, the phenomenon of refraction. Design exercises. Fundamentals of surveying calculations. Angular measures. Scales and graduations. Distance measurement with steel tape and electro-optical rangefinder. Calculus of coordinates on the plane - clearly determinable structures (angular intersections forward and backward, linear intersection, rectangular offsets). Polygonization. Initial error messages, equally and unequally accurate observations, weighting, calculation of the mean error of the observation function. Approximate alignment of strings and traverse networks. Electronic devices for large-scale mapping. Development of the map first draft. Calculating the surface area
10b	Basics of Surveying 2	Large-scale map (traditional and numerical), the process of its creation. Basics of construction of geodetic instruments (theodolite, leveler, electronic total station). Methods of checking and rectifying instruments. Methods of geodetic measurements to the extent necessary to make the main map. Classification of field details and technical regulations for their measurement. Designing, setting up, measuring and calculating detailed networks. The influence of the environment on the results of geodetic measurements, the phenomenon of refraction. Design exercises. Preparation of a contour map using the classical method (based on the provided measurement results). Preparation of longitudinal sections and cross sections based on the data provided. Geometric leveling - checking and adjusting levels. Performing technical leveling of benchmarks. Construction of theodolite - checking and rectification. Construction of an electronic total station. Measurement and calculation of the measurement network. Measurement of field details.
11a	Detailed surveying	LECTURES: Trigonometric leveling in detailed measurements. Determining the difference in height on the basis of the oblique and horizontal length for one-sided observations, taking into account the influence of the curvature of the Earth's surface and refraction. Determining the difference in height on the basis of bilateral and synchronous observations. Analysis of the accuracy of the difference in height determined by the trigonometric leveling method. Ways of determining the refractive index. Ways of determining the height of an inaccessible point. Application of trigonometric leveling for measurements of height matrices. Situational and altitude measurements using the tacheometric method and development of large-scale maps. Principles of developing large-scale maps, with particular emphasis on updating the main map on the basis of measurement using the tacheometric method. Organization of tacheometric measurement. Principles of generalization of details and relief during measurement. Classic and modern measurement network (total stations, block matrix, free tacheometric stations). Total stations (historical outline). Electronic total stations (construction, rectification and measurement principle with electronic total stations). Direction reading and measuring systems in electronic theodolites - repetition. Patterns for horizontal distance and height difference. Standard functions and special programs of electronic total stations. Analysis of the accuracy of tacheometric measurements. Location and altitude measurement technologies based on field coding. Situational and altitude measurements using the GNSS method in RTK mode. PROJECT: Determining the height using the trigonometric leveling method on the basis of the oblique and horizontal length for one-sided (taking into account the influence of the Earth's curvature and refraction) and synchronous two-sided targets. Analysis of the accuracy of determining the difference in height using the trigonometric leveling method. Preparation of observations for the equalization of the trigonometric leveling network. Determination of the height of an inaccessible point. Situational and altitude measurements using the tacheometric method. Electronic total stations; measurement functions and calculation procedures, establishing free tachymetric positions, situational and height measurements based on field coding, computer processing of measurement data. Analysis of the accuracy of tacheometric measurements. Development of a situational and altitude map based on tacheometric measurements (large-scale numerical map with the geo4ce program).
11b	Detailed surveying 2	LECTURES: Detailed warp. Surface angular-linear networks (design, interview, stabilization). Angular measurements in surface networks. Assessment of the accuracy of measurements of directions and angles. Station alignments of directions and angles. Ferrero pattern. Methodology of linear measurements in detailed matrices. Field methods of checking the electro-optical rangefinder addition constant. Geometric and mapping reductions of the lengths measured with an electro-optical rangefinder. Eccentric measurements. Eccentric corrections for directions, angles and lengths. Analysis of the accuracy of eccentric measurements. Development of a geodetic network on a plane in the Gauss-Krüger projection. Helmert transformation. Elements of the design of geodetic networks. Accuracy analysis of basic geodetic structures. Detailed horizontal network established by the polygonization and polygonotriangulation method. Analysis of the accuracy of the location of points in a traverse (longitudinal error and transverse error of a point in a hanging and connected sequence). PROJECT: Measurement of angles using the directional method. Preliminary development of the measured angles and directions (station alignments, assessment of the accuracy of angular measurements). Geometric and mapping reductions of the lengths measured with an electro-optical rangefinder. Reductions of directions, angles and lengths measured eccentrically. Determination of eccentric elements by indirect method. Analysis of the accuracy of eccentric measurements. Development of a geodetic network on a plane in the Gauss-Krüger projection. Helmert transformation. Analysis of the accuracy of single indentations using the accounting and graphic method.
12a	Engineering and Industrial Geodesy	Introduction to the specifics of issues related to Engineering and Industrial Geodesy. Geodetic works at the stage of preparation of a construction project for various engineering objects h. Geodetic development of the project at the initial and detailed level. Rules for determining the required accuracy of the implementation of a construction object . Implementation, design, accuracy and reliability analysis. Methods and technologies of setting out. Assessment of the setting out in geodetic structures. Methods of detailed control in various phases of construction implementation. Measurement methods and techniques in inventory work on the control of various building objects and structures. Geometry of road routes and rounding of the refraction of routes in the horizontal plane . Transient curves as an element of the kinematics of vehicle movement on the roads . Industrial cranes (cranes) and control of their geometry. The scope of inventory measurements of the crane system. Methods for measuring and determining the alignment of track systems. Project topics: geodetic development of the design of an industrial plant, including, geodetic development of the design of the curvilinear section of the road route, solutions for the layout of the interchange section of the railway route with turnouts and inserts. Examination of the verticality of the building with selected measurement techniques. Measurements and elaboration in the field of flatness control of the building structure element. Development of a fragment of the road route using a clotoid, as a transition curve and determination of the coordinates of the main and detailed points of the road lane on this episode. Geodetic development of measurements of the crane track with the determination of routing corrections using linear regression. Analytical and graphic elaboration of the results
12b	Engineering and Industrial Geodesy 2	Tasks and methods of performing control measurements of buildings. Designing implementation measurements and assessing the accuracy of these measurements. Control measurements at various stages of construction implementation. Introduction to performing preliminary accuracy and reliability analyzes. Reliability of geodetic networks. Geodetic works related to the design and implementation of communication routes, including road, rail and metro. Geodetic development of collision-free road junctions. Surveying service for the construction of an industrial hall. Inventory and control measurements of slender structures, bridges and viaducts. Remote Measuring Systems. Hybrid techniques. Geodetic measurements on unstable objects (ships, docks). Instrumental standards PN / ISO 17123-1 to 17123-10. Design topics: Geodetic development of a collision-free road junction design, Solution of the geometry of the lane widening of transverse and longitudinal declines, cant on ramp sections. Introduction of transition curves of various parameters. Determination of the coordinates of all characteristic points of the route. Designing the implementation network and assessing its accuracy. Preparation of documentation sketches and stake sketches for individual elements of the study. "Zero measurement" and fitting the construction grid of the building into the previously realized foundation. Development of the measurement results of the verticality of the industrial chimney axis using the directional (angular) method and the precise method. Preparation of a graphic design in the appropriate Monge projections.
13	Electronic Measurement Techniques in Geodesy	Electromagnetic waves: Spectrum and properties of electromagnetic waves. Wave range used in geodesy. Fundamentals of metrology. Absolute laser distance meter, a basic principle of operation and their classification. Pulse laser distance meter, the timing problem. Phase laser distance meter: wave sources, modulation, photodetectors, reference frequency generators, photometers. Radio wave distance meter, the principle of measuring pseudo-range to satellites. Propagation of electromagnetic waves: Atmospheric refraction and its influence on length measurement. Measurement of meteorological conditions. Resistance and thermoelectric thermometers. Aspiration psychrometers. Aneroids and barometers. Distance measurement errors. Comparison of distance meter instruments. Application of the interference phenomenon in geodesy. Electronic theodolites. Electronic angle measurement methods: code, dynamic and pulse. Vertical axis tilts compensation methods. Electronic total stations. Lasers: the use of lasers in geodesy. The basic principle of the operation of laser scanners. electronic code levelling instruments: the principle of construction of the levelling instruments and levelling staffs. Types of power sources. Selection of the power source. Unit of length. Determining the accuracy of time measurement - impulse distance meter. Construction of the distance meter - disassembly of the distance meter. Measure the frequency modulation. Determining the frequency correction. Phaseometer. Measurements with phase distance meter (Topcon, Leica, Sokkia, Nikon). Determining the prism constant. Working formulas for determining atmospheric correction. Measurements of temperature, pressure and humidity - comparison of meteorological instruments. Electronic theodolites. Determination of collimation and inclination. Testing the accuracy of the angle measurement. The use of the interference phenomenon in geodesy. Measurement of the length increment with the Michelson interferometer. Calibration of the code levelling instruments (DiNi12, Wild NA2003). Transmission of measurement data to a computer (RS232, USB etc.).
14a	Geodesy	Lecture: Introduction to geodesy: land surveying and geodesy, the shape of the Earth, an introduction to physical geodesy, the concept of height systems, the natural coordinate system. Rotational ellipsoid as a reference surface: fundamental relationships on the ellipsoid's surface, geodetic coordinates, geodetic line and normal sections, calculation of coordinates, the direct and inverses problems on the ellipsoid. Transformations of GNSS measurement results: introduction to transformation, 7-parameters transformation, affine transformation, the transformation of geodetic latitude and longitude coordinates. Reductions of coordinates obtained from GNSS measurements on the reference surface: direct reduction to the ellipsoid surface, reduction in the gravity field, Gauss-Krüger and UTM maps, reductions to the projection plane, PL-2000 ', PL-1992 and PL-1965 systems. Laboratory: the geometry of the ellipsoid: spherical excess, ellipsoid parameters and basic relations between them, normal sections and geodesics, geodetic, geocentric and reduced coordinates, conversion between geodetic, Cartesian and topocentric geodetic coordinate systems (φλH <-> xyz <-> NEU), transfer of coordinates: direct task and inverse task - Kivioji and Vincent methods, geodetic reference systems, coordinate transformations between different systems. Converting geodetic coordinates to state plane coordinate systems; reductions of the observation to the ellipsoid and the projection plane.
14b	Geodesy 2	Lecture: Gravity field models: elements of potential theory, boundary problems of potential theory, expansion of the potential into series of spherical harmonics, the normal gravity field, geodetic reference frame GRS'80, theory of normal spheroid, geodetic effects of tidal phenomena. Outline of the theory of the figure of the Earth: gravimetric reductions and gravimetric anomalies, the basic equation of physical geodesy, the outline of Stokes theory, deflection of the vertical (vertical deviation), astronomical-gravimetric levelling, height systems (dynamic and orthometric heights), the Molodensky concept - normal heights. Changes in the field of gravity with time: tidal force potential, reform potential, geodetic effects of tidal phenomena. Geodetic reference systems: European reference system EUREF, EUREF-POL and POLREF networks, problems of the orientation of reference ellipsoids, European height reference system EVRS. GPS satellite levelling: global, regional and local approaches. Ties the local observation systems with the global system: traverses between satellite points, coming to Total Station measurements. Introduction to the problems of geodynamic research. Project: Precise levelling: technology of levelling measurement, measurement of the height difference on the bench, basic levelling network, checking and adjusting the leveler, measuring the leveling section, developing the results of level measurements, laboratory and field comparison of levelling staffs, analysis of the accuracy of the levelling network measurement, principle of code levellers. Trigonometric levelling: preparation of electronic total stations, measurement technology of trigonometric levelling, trigonometric levelling taking into account the gravity field, the problem of refraction in trigonometric levelling. Power supply for surveying instruments. GPS satellite levelling: geometric heights versus orthometric heights, determination of the geoid height in relation to the WGS-84 ellipsoid, methods of determining the geoid inclination in small areas.
15	Geodetic Astronomy and Geodynamics	Lectures: 1) Introduction: astronomy as a discipline, geodesy and geodetic astronomy. Astronomy is the oldest natural science - a historical outline of the development of astronomy and geodesy (studies of the shape and size of the Earth). Spherical astronomy. 2) The Earth and its place in the universe. The structure of the Universe, the Galaxy, the Solar System. 3) Basic coordinate systems used in geodesy and geodetic astronomy. Orthcartesian, spherical and ellipsoidal system. Definitions of spherical coordinate systems: geographical, equatorial, hourly and horizontal. Astronomical and ellipsoidal geographical coordinates: vertical deviation. 4) The rotational and orbital motion of the Earth and the apparent diurnal motion of the celestial sphere and the apparent annual motion of the Sun. Phenomena of diurnal movement of the celestial sphere. 5) Phenomena resulting from the rotational and orbital movement of the Earth and their impact on the observed positions of celestial bodies (stars, planets, artificial satellites of the Earth) - aberration and parallax. Refraction for waves in the optical and radio spectrum. 6) Mean sidereal time and real sidereal time, real solar time and average solar time - definitions, dependencies. Longitude-based time dependence, universal time, and zone times. Atomic time, GPS time, coordinated universal and universal time (TU0, TU1, TU2, TUC), the relationship between universal time and the parameters of the Earth's rotation (Earth's angle of rotation ERA). 7) The average, apparent and actual coordinates of celestial bodies. Astronomical catalogues and annuals. 8) Geodynamic basis of reference frames. Why in geodesy do we use two frames of reference. International Celestial Reference Frame (ICRF), International Terrestrial Reference Frame (ITRF). The International Earth Rotation and Reference System Service (IERS) and its responsibilities. The coordinate transformation from ICRF to ITRF. Observation techniques: VLBI, SLR, LLR, GNSS. Models of movement of tectonic plates. Transformation of Earth coordinates from epoch to epoch. 9) Elements of celestial mechanics: the movement of celestial bodies, the limited task of two bodies, Kepler's laws. 10) Tidal phenomena in geodesy and astronomy. Exercises: 1) Basics of spherical trigonometry. 2) Astronomical coordinate systems. The transformation between systems. 3) Diurnal movement of the celestial sphere – analysis of phenomena: east and west, culminations, passage through the first vertical and elongation, twilight. 4) Circadian movement of the Sun. Calculation of sunrise and sunset parameters. 5) Astronomical Yearbook, star catalogues, astronomical software. 6) Tenses used in astronomy and geodesy. Time conversion. 7) Differential formulas of spherical trigonometry. Ephemeris. 8) Apparent places of celestial bodies. Analysis of phenomena affecting changes in apparent coordinates. Analysis of astronomical methods of determining position and azimuth. Algorithms for reducing observations in different cases.

16	Satellite Geodesy	Lecture: the theory of the motion of artificial satellites: Keplerian and perturbed motion; Kepler's laws; elements of the orbit; types of orbits; equation of motion; integration of equations of motion; movement in circular and elliptical orbits; Kepler's equation; orbital and geocentric coordinates of the satellites; elements of a circular orbit; satellites ground track; geostationary satellite and its applications; perturbed satellite motion; classification of perturbing forces; oscullatory elements; secular, long-term, short-term and diurnal perturbations; perturbations caused by the eccentric gravitational field and the atmospheric effect. Techniques of artificial satellites observation: classification of observation techniques; principles of the satellite laser ranging (SLR), altimetric and gradiometric measurements; basic information about photographic and Doppler techniques. GNSS measurements: the architecture of GNSS systems; GNSS satellite signal structure; receivers and antennas; code and carrier-phase method of measuring the distance to a satellite. Initialization problem in GNSS measurements; absolute and relative methods. GNSS measurement technologies: static, fast static, kinematic, RTK/NRTK and DGNSS; GNSS measurement errors; the differencing of GPS observation (single-, double, triple difference), linear combinations of the carrier-phase observations and their applicability and their advantages and disadvantages. Other existing and planned global satellite navigation systems: GLONASS, Compass and Galileo systems; system similarities and differences; the benefits of using them together. Overview of regional satellite navigation systems: EGNOS, QZSS, IRNSS GAGAN etc. Satellite and Ground Augmentation Systems, national augmentation system ASG-EUPOS. A brief overview of currently operating satellite missions (DORIS, GOCE, CHAMP, GRACE). Laboratory: the theory of the artificial satellite motion; determination of horizontal coordinates of a geostationary satellite; determination of the geocentric coordinates of the GPS satellite based on the broadcast ephemeris; calculation of DOP parameters; planning and field measurement with the use of static and fast static technology; GNSS data processing - vector determination and GNSS network adjustment; quality evaluation of the results; preparation and field measurement with the use RTK/NRTK technology; ASG-EUPOS services - rules of use and data formats.
17a	Adjustment Calculus	Estimation theory. Types of errors and uncertainties. Geodetic network as a series of points and measurements. Elements of algorithms. Solving of numerical problems with use of Matlab/Octave programming environment.
17b	Adjustment Calculus 2	Methods of adjustment and uncertainty estimation. Parametric and conditional methods. Linearization on non linear problems. Mixed methods of adjustment. Adjustment of correlated measurements. Adjustment of classic geodetic levelling and planar networks. Solving numerical problems with use of Matlab/Octave enivronment.
18	Land Information Systems	LECTURES: Characteristics of spatial data. Spatial data models. Spatial data infrastructure (data and services). The website www.geoportal.gov.pl and its role in the infrastructure of spatial information. Technical aspects of WMS / WMTS / WFS network services. Spatial information systems. Legal bases to ensure that the data in the land information systems is up-to-date. Organization of spatial data. Bounding rectangles. Spatial indexing. Methods of obtaining data for information systems about the area. Spatial data analysis. Mathematical mechanism of data analysis (elements of computational geometry). Providing data from PZGiK. Legal aspects of data sharing. LABORATORY EXERCISES: Practical familiarization with the website www.geoportal.gov.pl. Practical use of spatial data and related services. Getting to know the basic functions of the software used to maintain databases of terrain information systems. Data analysis in terrain information systems: searching and selecting data based on geometric and descriptive conditions. Preparation of a fragment of a numerical basic map on the basis of field sketches. Calibration of rasters using various transformation models. Vectorization of a part of the basic map.
19	Fundamentals of Photogrammetry	Photogrammetry - definition. Aerial cameras. Measurement properties of aerial photos. Elements of internal camera orientation: elements of the central projection, the image coordinate system of the analogue camera, basic elements of internal camera orientation, spatial camera coordinate system, the image coordinate system of a digital camera. Radial distortion of the lens. Tangential distortion of the lens. Points and line of interest of a tilted image. Geometric properties of the aerial photo. Elements of external orientation of a photo. Systematic errors of photos. Aerial photos acquisition, quality, basic parameters of the photo block, designing the scale of photos, time of day and photographic season, photo mission management system. The quality of modern aerial photographs. Comparison of the spatial resolution of analogue and digital photos. Country coverage by aerial photographs. Stereoscopy - observations vs. measurement. Conditions for stereoscopic observations. The concept of a measurement mark. Stereoscopic observations and stereoscopic measurement. Simplified altitude compilation of the stereogram of aerial photographs. Image coordinate system of photos: definition and measurement. Automatic photo measurement (image matching). Introduction to analytical photogrammetry. Elementary analytical operations on photos: photo rotation matrix, spatial coordinate system of a photo (camera), the condition of collinearity, spatial resection (calculation of elements of external camera orientation), spatial intersection. Introduction to aerotriangulation.
20	Photogrammetric Measurement Technologies	Stereoplotter processing of the stereogram of analog aerial photos. Image Matching. Digital photogrammetric workstation - DPW. Aerotriangulation. Digital Terrain Model - DTM. Airborne laser scanning (ALS). Digital orthophotomap. Vector studies. Photogrammetric supply of topographic databases. Satellite imaging in the optical range. Satellite imaging with a very high resolution (VHRS). 3D modeling. City model.
20	Photogrammetric Measurement Technologies 2	Stereoplotter processing of the stereogram of analog aerial photos. Image Matching. Digital photogrammetric workstation - DPW. Aerotriangulation. Digital Terrain Model - DTM. Airborne laser scanning (ALS). Digital orthophotomap. Vector studies. Photogrammetric supply of topographic databases. Satellite imaging in the optical range. Satellite imaging with a very high resolution (VHRS). 3D modeling. City model.
21a	Remote Sensing	Lecture: Physical basics of remote sensing. Energy relations between Sun - object - sensor. Absorption bands in the electromagnetic spectrum and atmospheric windows used in remote sensing. Spectral characteristics of objects: measurement methods, spectral curves of typical objects and the influence of various factors on their course, the meaning of spectral characteristics knowledge in remote sensing. Aerial images: panchromatic, black-and-white infrared, color, color-infrared and multispectral. Characteristics of images in terms of interpretation tasks. Methodology of aerial image interpretation, typical relations: object - the look of object in different images. Visual and digital methods of interpretation, the logic of image interpretation. Aerial and satellite scanners: methods of imaging using scanners, the essence of digital format, image structure in digital format. Basic information on meteorological, optical and radar satellites. Characteristics of selected satellite systems, including Landsat, SPOT, Sentinel-2, WorldView, GeoEye, Plejades, Radarsat, TerraSAR-X. General information concerning digital image processing, color composite, image classification, creating a satellite map. Examples of remote sensing techniques usage in various fields of the economy. Remote sensing data as a data source for GIS. Exercises: Recognition and interpretation of objects in aerial images in selected band of the visible spectrum and black-and-white infrared images, the relation between spectral characteristics of object and its shade of grey in the image. Relations between shades of grey in the optical (visible spectrum) and infrared images. The update of selected elements in indicated spatial database using open-access remote sensing data. Basics of creating color composites. Landscape analysis on Sentinel-2 color composites. Creating image interpretation key based on satellite images.
21b	Remote Sensing 2	General Introduction to software. Raster images - basic features, notation, formats, metadata. Image visualization, the concept, and role of the histogram. Image quality improvement; contrast enhancement with a linear function and non-linear functions, visual evaluation of the quality of processed images. The creation of color compositions in various combinations and the overall assessment of the information content - the importance of selecting specific channels, selecting the contrast enhancement function, and the RGB filters assignment method. Interpretation of the image of color composition and the knowledge of spectral characteristics of objects. Vegetation condition analysis using the NDVI and TASSCAP index. Combining panchromatic and multispectral images - examples using the following methods: RGB transformation => HLS => RGB, val. the mean of (MS + PAN). Digital classification of land cover forms in a supervised approach - initial assumptions, class definition, preparation of training fields, analysis of statistics (signatures), assessment of the correctness of classes and preparation of training fields, classification with the use of selected algorithms. Assessment of the accuracy of the thematic digital classification of land cover classes.
22	Principles of Map Projections	Lecture: Introduction to mathematical cartography, the concept of the original surface in cartographic projection, coordinate systems. The concept of regular surface-to-surface mapping and cartographic projection. Elements of the theory of distortions in cartographic projections: particular scale, main scale and elementary scale of mapping distortions. Elementary scale of length distortion as a function of the directional angle. Tissot's theorem I - the concept of principal directions of a mapping. Tissot's theorem II - the concept of an ellipse of projection distortions. Extreme length distortion in the principal directions of the projection. Elementary scale of field distortions. The concept of meridian convergence, distortions of directions and extreme distortions of angles. Map projections reductions. Classification of cartographic projections depending on local projection distortions. Classification of cartographic projections depending on the shape of graticules- the class of multi-conical projections. Perspective map projections. Theoretical foundations of conformal mappings: isometric coordinates, theorem on conformal mappings, elementary length scale in conformal mappings and meridian convergence. General characteristics of cartographic projections used in geodesy and cartography. Gauss-Krüger mapping and its analytical forms. Project: Construction of a mapping grid in a given projection. Study of the nature of mapping distortions: lengths, directions, angles, surfaces. Determining the reduction of the geodetic figures in map projections.
23	Topographic Cartography	Lectures: Elements of topography, basic features: real terrain object, topographic object, topographic data. Conceptual model of topography, data model and types of reality notations: DLM, DCM, DIM. Basics of the topographic data bases designing. The rules and sources of topographic data acqusition. Features of contemporary Polish reference spatial databases. DTMs and they features and applications: methods of surveying, modeling and visualization. Problem of generalization of topographic data. Updating of topographic data recoures. Coordinate systems used in topographic models. Civil and military topographic databases. Database management system of BDOT10k, rules of its updating. Projects: 1.Using the mathematical rules of sheet of civil topographic map. 2.Structure of BDOT and analysis of data. Selection with SQL and spatial operators, selection by attributes, cartographic visualization of results. 3. Updating the topographic database (BDOT) using ortophotomap by WMS - exemlpary objects. 4. Cartographic visualization of topographic data - elements of topographic map 1:25000 using BDOT as a data source.
24	Fundamentals of Cartographic Visualization	Lectures: principles of cartography, map definition, cartographic visualisation and cartographic publication definitions, basics of graphics, methodology of cartographic presentation, cartographic generalisation, writing on a map, reference and thematic databases, editing process and reproducing maps in geographic information systems. Project classes: rules for choosing a cartographic presentation method, including a measurement scale, a system of symbols and visual variables depending on the purpose of the map and source data, cartographic visualisation techniques in GIS environment, updating the geodatabase and spatial analysis for the needs of an interactive map, statistical analyses, elements of thematic map sheet composition.
25	Fundamentals of Soil Science	Soil - its functions, the importance of soil science in geodetic works. The components of the soil - a short description. Physical and chemical properties of soils. Factors and processes shaping soil, its quality and usefulness. Characteristics and distribution of soil parent rocks occurring in the territory of Poland. Soil morphology. Characteristics of diagnostic levels. Soil formation processes. Systematics and characteristics of the most important types of soil. The geography of Polish soils. Soil index assessment - valuation and agricultural usefulness of soils, valorization of agricultural production space. FAO-WRB soil classification in relation to the systematics of Polish soils. Identification and inventory of soil degradation threats.
26	Introduction to Earth Science and Geomorphology	This course introduces the basics of Earth sciences, principles of geology, and geomorphology. Participants will learn about the structure of the Earth, the processes of formation and destruction of the Earth's crust, and theirs influence of these processes on terrestrial landscapes. LECTURE: Earth sciences; basics of geology; mineral, rock, and soil; structure of the Earth, plate tectonics, formation and destruction of the lithosphere; basics of tectonics; igneous processes; metamorphic processes; geomorphology: weathering, erosion, and sedimentation; basics of the geological structure of Poland; thematic maps as sources of geodata: geology, hydrogeology, engineering geology, and geomorphology.
27	Principles of Ecology and Environment Protection	The aim of this course is: i) to provide knowledge in the field of selected areas of ecology, enabling understanding of the processes taking place in the natural environment; ii) understanding the relationship between the components of the environment; iii) assessment of the impact of the natural environment on the directions of spatial development; iv) identifying barriers to socio-economic development resulting from environmental constraints. LECTURE: Functioning and characteristics of the natural environment. Basic concepts of ecology and environmental protection. Indicators determining the ecological functions of the environment - the potential of the environment and the capacity of the environment. Characteristics of ecosystems and mutual relations between biotic and abiotic elements of the environment. Selected departments of ecology. Ecology and its relationship with various fields of knowledge. Ecosystem structure, functioning, and productivity. Equilibrium states and threats to the natural environment. Factors limiting the development of organisms. Pollution and harmfulness threshold. Ecological succession and its importance in the natural environment. Biogeochemical cycles. Selected problems of the degradation of the natural environment. Degradation and protection of environmental components: atmosphere, lithosphere, pedosphere, hydrosphere, and biosphere.
28	Cadastre	Lecture: Legal basics of the functioning of the cadastre, and organisational structures of cadastre functioning. Cadastral division of the country: cadastral unit, cadastral district, parcel. Basic concepts: real estate, land real estate and registered parcel, building real estate and building, premises real estate and independent residential or other purpose premises. Collections of information on land, buildings, and premises in the cadastre, and sources of obtaining data. Sources of data for numerical description of boundaries of a registered parcel – technical and legal issues. Documentation from the establishment of the cadastre, and the possibility of its use among others for the numerical description of boundaries of a registered parcel. Data concerning entities in the cadastre, and source of data on the entities. Land use classification. Reports reflecting cadastral data. Rules of establishment of an existing cadastre, and rules of its continuous updating – formal legal and technical conditions. Rules of modernisation of the cadastre. Connections of the cadastre with land register and the fiscal cadastre system. Laboratory practice: Establishment of a real estate cadastre for a selected surveying district. Preparation of documentation necessary for the establishment of a land register. Analysis of the structure of land register, including preparation of a report from analysis of a selected land register.
29	Rural Management	Introduction: land real estate vs. registered plot, rea estate boundary vs. boundary of a registered plot, land and mortgage register vs. cadastre, legal status of real estate vs. ownership status, documentation confirming the legal status of real estate, and documentation specifying the course of boundary lines. Determination of the course of boundaries of registered plots. Demarcation of real estate in administrative and court proceedings. Divisions of real estate... Approval of boundaries for real estate division. Division of agricultural and forest real estate. Renewal of boundary marks and determination of boundary points. Rules of reporting surveying works and submission of their results to ODGiK. Rules of collecting technical documentation. Forest information system. Forest numeric map. Demarcation of real estate and renewal of boundary marks of state-owned forests. Land consolidation. Purposes of consolidation, course of proceedings, tasks of the district governor, tasks of the surveyor, land estimate, project rules, consolidation documentation, assumptions for a consolidation project, field studies, project, consolidation effects.
30	Real Estate Management	Obtaining knowledge in the scope of legal basics of management of real estate of the State Treasury and territorial self-government units, real estate expropriation and acquisition of real estate for the implementation of public purposes pursuant to special provisions. Lecture: Competences of public administration authorities in the scope of real estate management. Real estate resources. Public purposes in real estate management. Real estate expropriation. Return of expropriated real estate. Turnover of real estate constituting property of the State Treasury or territorial self-government units. Real estate pre-emption right. Priority right to purchase real estate. Land division. Land consolidation and division. Betterment levy. Acquiring real estate by foreigners. Enfranchisement of legal persons. Transformation of the perpetual usufruct right into real estate ownership right. Special provisions in real estate management.
32	Spatial Planning	1. The spatial planning system in Poland. 2. Planning documents prepared at the local level. 3. Procedures for preparing a study of the conditions and directions of spatial development and a local spatial development plan. 4. Social participation in the process of preparing planning documents. 5. The degree of detail in planning arrangements regarding, inter alia: the principles of division into building plots; lines, parameters and indicators of the building and communication service. 6. Planning situation of communes in Poland. 7. Urban and Architectural Commission. 8. Decision on building conditions. 9. Decision on the location of a public purpose investment. 10. Economic analysis of the implementation of the local spatial development plan.

33a	Block B - Facultative class of limited choice /E (Geographic Information Systems) GIS Applications	GIS lectures: Defining GIS. Towards and definition of GIS. GIS and other inoframtion systems. Data and Information. Evolution of the definition and conceptual scope. GIS components. Spatial Data Models (vector and raster data models). Sources of data (topo maps, aerial and satellite images, spatial databases). Relation between GIS, Cartography, and Location-Based and Navigation Services. Lab Exercises: Practical implementation of the selected issue using SIP software, taking into account the needs of the selected local government unit. Getting to know the organizational structure of the unit chosen. Analysis and selection of data for project implementation. Realization of the GIS project using the collected DTM data, topographic maps, satellite images. Students prepare project documentation that helps them understand the various stages of the project. Students make a prototype of the system - a spatial database, geo visualize data, and implement selected elements of the system interface. Preparation of visualization: thematic map, geoportal.
33b	Block B Facultative class of limited choice /E (Geographic Information Systems) GIS Thematic Applications	GIS lectures: Defining GIS. Towards and definition of GIS. GIS and other inoframtion systems. Data and Information. Evolution of the definition and conceptual scope. GIS components. Spatial Data Models (vector and raster data models). Sources of data (topo maps, aerial and satellite images, spatial data bases). Thematic spatial databases. GIS Applications in Poland. Selection of available data from state data resources. Lab Exercises: The project is intended to provide a deeper understanding of a GIS application through hands-on experience. The project will investigate a particular research problem using GIS software from class. Practical implementation of the environmental issue with the use of GIS software. Inventory and selection of data to achieve the main goal, conversion of data obtained for the project, acquiring new data, planning and conducting spatial analyzes. At all project meetings, students complete the document by entering the activities performed and the obtained results required to implement the following stages of the classes. The paper prepared by students aims to introduce them to the PRINCE2® project management methodology.
34a	Block C Facultative class of limited choice (Geodetic displacement measurements) Geodetic displacement measurements	Basic concepts and definitions: displacement, deformation, reference system - external and own, control network for the study of displacements, identification of the reference system, calculation of displacements. Reasons for the formation of displacements and deformations. The specificity of geodetic displacement measurements. Determination of vertical displacements by the precision leveling method. Determination of horizontal displacements: incomplete trigonometric network, full trigonometric network, angular-linear network, straight line method. Examples of applications of the GPS technique for the study of horizontal displacements. Development of measurement results for absolute vertical displacements determined by the precision leveling method. Determination of absolute horizontal displacements with the use of an angular-linear network. Determination of horizontal displacements using the incomplete trigonometric network. Geodetic interpretation of the results of displacement measurements. Methods of measuring relative displacements. Automation of displacement measurements.
34b	Block C Facultative class of limited choice Geodetic displacement measurements (Monitoring of Displacements of Objects at Risk)	Basic concepts and definitions: displacement, deformation, reference system - external and own, control network for the study of displacements, identification of the reference system, calculation of displacements. Reasons for the formation of displacements and deformations. The specificity of geodetic displacement measurements. Monitoring the movements of endangered objects. Determination of vertical displacements by the precision leveling method. Determination of horizontal displacements: incomplete trigonometric network, full trigonometric network, angular-linear network, straight line method. Application of GPS techniques to the study of displacements. Development of measurement results for absolute vertical displacements determined by the precision leveling method. Determination of absolute horizontal displacements with the use of an angular-linear network. Determination of horizontal displacements using the incomplete trigonometric network. Geodetic interpretation of the results of displacement measurements. Methods of measuring relative displacements. Automation of displacement measurements.
35a	Block D Facultative class of limited choice Real Estate Valuation	Lecture: Concept of the real estate market, types of markets, factors shaping the market. Introduction to real estate appraisal, concept and purposes of real estate appraisal. Real estate value as the basis for appraisal (market value, cadastral value, replacement value, other types of value). Legal regulations related to real estate appraisal. Approaches, methods, and techniques of real estate appraisal in Poland, and rules of their application: Comparative approach (pairwise comparison method, method of correcting the average price, method of statistical analysis of the market), income-oriented approach (investment method, profits methos, technique of simple capitalisation, technique of discounting streams of income), cost-oriented approach (replacement cost method, substitution cost method, detailed technique, technique of elements of integrated circuits, index technique), mixed approach (residual method, method of land estimation indices, liquidation costs method). Sources of information for the purposes of real estate appraisal. Features of real estate affecting its value. Rules and course of preparation of an appraisal report.
35b	Block D Facultative class of limited choice Basics of Water Melioration	Concepts of water meliorations and their aspects. Purposes of conducting melioration measures. Division and characteristics of melioration works. Characteristics of the quantitative state and quality of melioration infrastructure in Poland. Water management pursuant to the principle of sustainable development. Shaping and protection of water resources, use of waters and management of water resources. Characteristics of water ownership and ownership of land under waters. Rules of water management in reference to the property of the State Treasury. Environmental objectives and rules of water protection. Water retention and anti-flood protection. Water meliorations in the context of the real estate management process in rural areas.
36a	Block E Facultative class of limited choice Introduction to Databases	Lecture: Classification of databases. Database versus database management system. Fundamentals of the relational database model (relations normalization, primary and foreign keys, 1:1,1:N, N:M relationships, integrity constraints, indexing). Fundamentals of the object model of databases. Introduction to database and information systems design methodology (including elements of UML). Fundamentals of SQL query language. Overview of database management software (commercial and open source). Security in database systems. Specifics of spatial data management - selected information on spatial data management and spatial data models. Exercises:Learning a selected database management system (MS Access, SQLite). Practical SQL language usage exercises in the environment of the selected database management system. Design and implementation of a database (conception, conceptual model, logical model, implementation - establishing a structure, introducing sample data, data search).
36b	Block E Facultative class of limited choice Introduction to Databases	Lecture: Revisiting and organizing knowledge of relational and object-oriented data model and SQL language. Basics of database design, including elements of UML language. General characteristics of selected database management systems (Oracle, MS Access, open source software). Introduction to spatial database design. Geometric object storage models. Methods of recording spatial data in selected GIS programs (e.g. ArcGIS, Geomedia) and spatial databases (e.g. Oracle Spatial). Methods of using external databases by GIS software. Spatial indexing. Spatial relations, spatial operators - extended SQL language. Exercises: Practices with the selected database management system (MS Access or Oracle). Practical SQL language exercises in selected database management system environment. Practice in using SQL query language extended by spatial operators in a selected GIS program. Design and implementation of a spatial database (conception, conceptual model, logical model, implementation - establishing a structure, introducing sample data, data search, developing documentation)
37a	Facultative class 2 - Internet Availability of Geodetic Data	State geodetic and cartographic repository. Legal basis for the functioning of the resource (Geodetic and Cartographic Law, Act on Spatial Information Infrastructure). Legal bases for sharing geodetic data. Fees. Reporting geodetic works and collecting fees. Web Services. Metadata. National, voivodship, county and commune geoportals. Visit to one of the Geodetic and Cartographic Documentation Centers for practical contact with the national repository.
37b	Facultative class 2 - Systematics,valuation and valorization of soil	Linking soil functions with land development. Sources of information about soils. Criteria and methods of soil evaluation. Soil valuation in Poland. Legal grounds for soil valuation. Natural basics of soil valuation of flat, upland and lowland areas and mountain areas, table of land classes. Classification survey. Soil and agricultural map, content, application. Annex to the soil and agricultural map. Update of classification and soil-agricultural maps. Application of soil maps. Assessment of soil hazards on the basis of soil maps. Agrochemical assessment of soils. Indicative methods of assessing agricultural production space.
37c	Facultative class 2 - Introduction to Navigation Cartography	Selected elementary concepts of navigation: heading, bearing, line of navigation, declination, deviation, selection of optimum trajectory, determination of position outdoors and indoors. Types of navigation (terestric, astronavigation, satellite, other). Role of cartography in the navigation process. Types and parameters of classic and mobile maps used in land, sea, inland and air navigation: coordinate systems, mapping, scales, content range, data models. Functionality of selected mobile navigation and location applications. Spatial data sources for maps and navigation systems. Selected issues of cartographic presentation on navigation maps and in navigation applications.
37d	Facultative class 2 - Selected Issuas of agriculture	The agrarian structure of Polish agriculture, the specificity of agricultural production, production directions. Equipping agriculture with basic means of production. Principles of agricultural space development. Tax burden on entities in agriculture. Agroecological basics of plant cultivation. Organization of the farm - a short description of the departments. Organization of the farm territory - evaluation elements. Economics and organization of production factors: labor force, fixed assets, current assets, depreciation, investments, investment efficiency, elements of agricultural balances. Economic calculation and its elements: production, inputs, costs. Farm income. Rural Development Program - overview of pro-development measures and the possibility of their implementation in relation to the state, including the area structure of Polish agriculture
37e	Facultative class 2 - Surveying and cartographic resources	General provisions of the Surveying and cartographic law. Surveying and cartographic services. Surveying and cartographic works. Land and building register. Surveying register of infrastructure networks. National surveying and cartographic resources. Professional entitlements and disciplinary responsibility. Register of municipalities, streets, and addresses. Penal provisions and fines. Fees for surveying and cartographic activities. Technical standards of performing site and height measurements, and processing and reporting results of such measurements to the national surveying and cartographic resources.
38a	Facultative class 3 - Adjustment of Observations	Multivariate variables, multivariate normal distribution, correlation, the first-order and the second-order regression, orthogonal regression. Verification of statistical hypotheses, nonparametric hypotheses, parametric estimation: estimator theory, estimation methods, estimation of expected value, estimation of variance. Variance analysis univariate classification, multivariate estimation by the least-squares method. The nonlinear equation, Gaussian method, orthogonalisation methods, Marquardt method. The most general case of alignment. Lagrange function, successive linearization, duality CLP observation code. List of NXY points. PointSearch function. Function observationCLP Modified Choleski-Banachiewicz algorithm with uncertainty control. Global test, detailed tests Parametric alignment. Aligned by conditional method, topological conditions. Row, stochastic, free parametric alignment with location conditions on unknowns
38b	Facultative class 3 - GNSS measurements in geodesy and navigation	Absolute and relative determination of positions from code observations - calculation algorithm. Development of satellite kinematic observations with the use of selected filtering algorithms. Augmentation systems (SBAS and GBAS augmentation systems) in GNSS measurements. The use of EGNOS and ASG-EUPOS systems in navigation. The use of NAWGEO, POZGEO and POZGEO D services of the ASG-EUPOS system and selected services of private reference station networks in geodetic works: purpose of the services and examples of their use. The problem of calibrating RTK measurements to a local system, altitude measurements with the use of real-time GNSS-RTN services. Examples of the development of satellite observations and the alignment of GNSS vector networks.
38c	Facultative class 3 - Utility Infrastructure Networks	The project classes contain: - review of the various types of utility infrastructure networks, - methods of geodetic measurement of the infrastructure elements, - presentation of the utility infrastructure networks elements on the maps, - Creation and maintaining of the GESUT (Geodetic Inventory of the Utility Infrastructure Networks), - methods of detection of the underground utility infrastructure elements.
38d	Facultative class 3 - Selected Topics of Environment Remote Sensing	The course is divided into two parts. In the first, the student becomes acquainted with selected methods of satellite image processing (multi, super and hyperspectral), such as: creating color composites for the needs of environmental analyzes - selecting the proper spectral ranges for specific purposes, creating masks of selected objects (e.g. water mask), statistical analysis of satellite images in global and local terms - advantages and disadvantages of both approaches, calculation of vegetation and soil indicies and their role in the natural environment research. In the second part of the course, students, in small teams, carry out a project aimed at analyzing and assessing the changes in the environment with the use of LANDSAT or Sentinel satellite data, using e.g. supervised classification and/or masking.
38e	Facultative class 3 - GIS Applications	The methodology of assessing investment options using SIP technology and spatial analysis. Developing an assessment and choosing the best strategy. Review of the literature in English on the selected scope of SIP applications. Preparation and presentation on the selected application of SIP technology. Performing a simple spatial analysis of a selected topic using SIP technology.
38f	Facultative class 3 - Field Exercises in Geodetic Astronomy and Selected Methods of Geophysical Prospection	Astronomical and geodetic measurements - determination of the geodetic latitude from the Pole Star, - determining the azimuth of the Earth target from the Pole Star, - determination of geodetic coordinates and geodetic azimuth based on static GNSS observations, - determination of the components deflections of the vertical of the plumb line. Geophysical measurements - determination of the density of surface formations based on the performance of gravimetric observations (Nettleton's method), - measurements using the method of seismic reflection along with geodetic service of such measurements, - measurements of the Earth's magnetic field with a vertical magnetic probe, - conductometric measurements, - surface gravimetric measurements, - GPR measurements, - geodetic service of geophysical works, - preparation of geophysical data: visualization, determination of anomalies, analysis of the residual field (inversion). Exercises carried out as part of a trip for 5 days (Mon-Fri, September period) combined with students of Geological Departments of the University of Warsaw at the Nicolaus Copernicus University in the Center of the European Geological Training Center in Chęciny. Classes are conducted in an interdisciplinary manner and include a lecture part, closely related to the program being implemented. Research objects are selected annually in the Chęciny region so that their results are useful.
38g	Facultative class 3 - Fieldwork on Photogrammetry and Cartography	Projects are realised in survey teams (3-4 persons) and takes 5 days. Fieldwork consist of two parts: 1. Photogrammetric - surveys using short-range methods and processing the results. Projets includes taking ground photos and terrestial scanning (TLS) of choosen building. Used systems: Z+F, CloudCompare and AgiSoft. 2. Cartographic - updating of Polish Topographic DataBase (BDOT) in several (12) feature classes. Project includes in-lab updating geometry and attributes of objects, using WMS data - actual orthophoto and field data acquisition on ~1 sq km area in the City of Warsaw (applications: QGIS or ArcGIS).
39a	Facultative class 4 - Spatial Data Infrastructure	Spatial data infrastructure (SDI), Spatial information infrastructure (IIP), Spatial knowledge infrastructure, INSPIRE, standards and norms for collecting and sharing spatial information and metadata. The role and functions of geoportals. Spatial data themes implemented within IIP in Poland.
39b	Facultative class 4 - Urban Geodesy	Discussion of ways to conduct urban maps, including: the basic map of the city, derivative and theorical maps and ways to update them. Performing complementary measurements, terrain profiles and maps for design purposes for urbanized areas. Geodetic development of a detailed spatial development plan for urban areas. Geodetic issues occurring in the land management of urban areas. Geodetic networks: horizontal basic, detailed, high-altitude notations - characteristics of the basic for the city. Implementation warns for the layout of streets, municipal routes, railway station, workplace, bridge or other engineering facility in highly urbanized areas. Ways of designing, putting on and conservation. Systems of stabilization of urban and implementation systems. Map for the purpose of the first . Regulations and rules for the implementation of design and executive studies. Systems for the implementation of the task in an analytical form along with a vector graphic presentation. Geodetic service for the construction of a residential investment erected using various techniques (from the traditional method through industrial methods to the sliding method). Construction and assembly panels for the implementation of construction services. Measurement techniques in geodetic operation of buildings. Examples of innovations in construction. Skyscrapers and technics their geodetic construction service. Road objects and flyover structures, bridges and viaducts in the city area and geodetic works at the design, implementation and operation stages. Control measurements Discussion of the principles of designing tec equipment and indirect methods and techniques of their detection. GESUT as a data collection system on technical utilities. Instructions and legal acts as formal documents regulating the rules of operation of the system. Metro as a legal system of communication and underground construction: – design and provision of a special framework, – construction of tunnels and elements of geodetic service of shield guidance , - control of the shape of the tunnel during and after construction,- monitoring of displacements of the building and their surroundings,
39c	Facultative class 4 - Fundametals of Engineering Photogrammetry	Discussion of the technological scheme of photogrammetric measurement: factors affecting the choice of the method - the type of desired information, the object's geometry, the type of control elements, the representativeness and accuracy of the measurement results and methods of registration of the object. Issues of calibration of digital cameras. Problems of spatial modelling of architectural and engineering objects. Fundamentals of ground scanning. Examples of photogrammetric systems used in various branches of the economy. Basics of digital image processing used in various engineering applications.

39d	Facultative class 4 - Computational Geometry	Preliminary concepts, historical background, basic definitions for computational geometry. Discusses the basic algorithms of computational geometry. Basic data structures used to solve geometric problems. Characteristics and recording of geometric objects. Properties and use of vector product in computational geometry. Approximate objects with bounding rectangles and index spatial data. The issue of the intersection of lines and sections. Geometric interpretation. Search in a set of intersecting pairs. Study the position of the point inside the polygon. Methods of solving the task - special cases. Create a convex wrapper of a set of points. Methods of solving the task. Finding a pair of the least distant points. Generalizing the shape of geometric objects. Create paths for surface objects. The issue of the intersection of polygons. Voronoi diagram and its application. The problem of triangulation of a set of points. Delaunay triangulation.
40a	Facultative class 5 - Industrial Measurement Systems	Preliminary information concerning: object features being measured due to legal and industry regulations, legal regulations concerning the implementation of the industrial measurement. Review of the law regulations concerning measurements of geometry for various engineering and industrial objects. Presentation of the methods and techniques of industrial measurements (optical and mechanical methods). Electronic measuring instruments and ultrasound measurement systems. Using laser devices in precise measurements. Application of interferometers and Laser trackers in industrial measurements. Hot kiln measurement systems. Geodetic instruments as elements of the automated measuring systems. ETIS (Electronic Theodolite Intersection System) and TC-calc (Polar measuring system) systems as a tool for the objects' geometry inspection. The general rules for the construction of the integrated measuring systems for conducting the automated measurement processes. Techniques and methods of data development and presentation of the automated monitoring measurements.
40b	Facultative class 5 - Application of photogrammetry and remote sensing	1. The use of satellite images for the condition assessment and Earth monitoring, - multispectral images and their applications, - super- and hyperspectral images and their applications, - thermal remote sensing and its applications, - SAR images and their applications. 2. Aerial data and their products available in Poland - status and coverage (digital terrain models, orthoimages, topographic databases) - coverage status, parameters, availability. 3. Airborne laser scanning - a source of data not only for hydrologists and surveyors - the use of ALS in technical, natural and human sciences. 4. Near-range photogrammetry in engineering and cultural heritage. 5. Data acquisition from UAV and their applications.
40c	Facultative class 5 - Multimedia and Three-Dimensional Cartographic Visualisation	General information: new scope of cartography task, cartographic visualisation, multimedia cartography, dynamic cartography, the concept of georepresentation, classification of georepresentations: two- and multidimensional, static and dynamic. Multimedia cartography: definition of multimedia, hardware and software, multimedia means of expression, the essence of typography, vector graphics, tonal images, sounds, compression algorithms, rules of multimedia compositions. Dynamic cartography: series of maps, multi-time maps, maps of variability of phenomena and processes, interactive maps, cartographic animations, films, the extension of the methodology of cartographic presentation in terms of time. Editing and development of multimedia presentations: rules of editing, concept, script, spatial, temporal and functional framework, legend, explanations and control fields, scope of presentation functionality. Tools and methods of multimedia publications, the specificity of sharing spatial data on the Internet, designing websites, the usability of publications.
40d	Facultative class 5 - Selected issues of real estate valuation	Approaches, methods and techniques of real estate valuation in Poland, including: types of approaches, methods and techniques of real estate estimation and the principles of their application. A comparative approach including: a method of comparison in pairs, a method of adjusting the average price, a method of statistical analysis of the market; An income approach including: the investment method, the profit method, the simple capitalization technique, the technique of discounting income streams; A cost approach including: the method of replacement costs, the method of replacement costs, detailed technique, integrated elements technique, indicator technique; mixed approach including: residual method, land appraisal rate method, decommissioning cost method. Valuation of undeveloped urbanized properties including: factors affecting the value of real estate intended for development, selection of the approach and method of valuation depending on the purpose of valuation, selection of information sources and databases, determination of the value of undeveloped urbanized properties. Valuation of real estate developed with single-family residential buildings including: factors affecting the value of real estate developed with single-family residential buildings, selection of valuation approaches and methods depending on the purpose of valuation, selection of information sources and databases, determination of the value of real estate developed with single-family residential buildings. Valuation of real estate developed with multi-family residential buildings and residential premises including: factors affecting the value of real estate developed with multi-family residential buildings and residential premises, selection of the valuation approach and method depending on the purpose of valuation, selection of information sources and databases, determination of the value of real estate developed with multi-family residential buildings and residential premises. Valuation of real estate developed with commercial, service and industrial facilities including: factors affecting the value of real estate developed with commercial, service and industrial facilities, selection of the valuation approach and method depending on the purpose of valuation, selection of information sources and databases, determination of the value of real estate developed with commercial, service and industrial facilities. Other issues important from the point of view of property appraisers making real estate valuations, i.e.: effective communication, assertive behavior and the ability to persuade.
41a	Facultative class 6 - Land Surveying and Licensing	Presentation of detailed rules of obtaining professional license in the scope of surveying and cartography in Poland resulting from the provisions of the act of 17 May 1989 – Surveying and cartographic law, and the currently binding regulation regarding professional license in the scope of surveying and cartography. Detailed presentation of the rules of documenting professional practice (running a professional practice log) and identification of minimum quantity and type of works necessary for recognising the practice as sufficient in particular scopes of license. Presentation of the rues of the qualification proceedings. Identification and classification of a set of legal and technical regulations the knowledge of which is necessary to obtain professional license in the scope of surveying and cartography, and familiarisation with selected examination subjects from selected aspects of the license (1 and 2). Presentation of the rules of running surveying and cartographic resources, including: rules of reporting surveying work, activities related to the service of the reported work in ODGiK (disclosing materials, verification, endorsing materials), activities of a surveyor in the scope of the procedure of performing the reported work. Presentation of the rules of performing works from selected assortments, i.e. staking out buildings, map for design purposes, post inventory of a building. Identification of legal regulations related to the performance of given work, and determination of the scope of activities to perform for particular units and entities participating in the implementation of the work, i.e. PODGiK and authorised surveyor.
46	Field Training in Fundamentals Surveying	Technical leveling of benchmarks - range from 0.5 to 1 km (depending on the difficulty of the terrain) per member of the measuring group. As part of the topic, checking and possible rectification of the level (automatic and code), preparation of topographic descriptions of benchmarks, and preparation of a measurement survey. Linking the leveling to benchmarks, the heights of which have been previously determined. Preparation of drawings of a longitudinal profile and cross-sections. Execution of the measurement survey. Situational and altitude map. Establishment, measurement and alignment of the measurement network connected to the national geodetic network. Site and height measurement of the area - the area depending on the degree of land investment (number of details) is determined by the trainer. The measurement is performed using the polar method without registering the results with electronic tacheometers or electromagnetic rangefinders attached to traditional or electronic theodolites - most often the equipment is exchanged between groups to familiarize students with various instruments. Preparation of a situational and altitude map.
47	Field Training in Geodesy and Satellite Geodesy	1. Establishing of detailed network and situationalmeasurements and height elements using the technique GPS/GNSS and RTK/RTN. 1.1. GPS/GNSS network project and design (detailed networks). 1.2. Assumption detailed geodetic base by the combined method: • assuming 4 points of the network using the measurement method static GPS/GNSS • checking the total station and rangefinder testing (determination of the prisim constant) • establishing a traverse between GPS points (electronic total station) by precise polygonization- minimum two points • joint study (adjustment) of the results of the GPS measurements and polygonization. 1.3. Situational and altitude measurements GPS-RTK method • transformation local (instantaneous) coordinate system to national system at the points of the network • detailed development of measurement results - preparation of a fragment of the base map by RTK/RTN method. 2. Leveling and gravimetric measurements in the base vertical network. 2.1. Leveling measurements in basic height network on the line leveling line between GPS points • clasical precise leveling measurements , method of satellite leveling. 2.2. Gravimetric measurement gravimetric benchmarks of leveling lines with relative method 2.3. Calculation of orthometric and normal corrections - calculation of orthometric and normal heights benchmarks on the leveling line. 2.4. Determination of the undulations of the geoid from the ellipsoid and height anomalies on selected line benchmarks level and comparison with obligatory geoid (quasi-geoid) model - satellite leveling. Accuracy analysis of the leveling line. Leveling precise trigonometric. 3. Completion of the final reports
48	Field Training in Detailed Surveying	Establishment, measurement and numerical elaboration of a bifunctional measurement network. Situation-elevation measurements by tacheometric method and by RTK method with automatic recording of measurement results and with coding of details in the field. Preparation of a large-scale numerical map in accordance with the standards of the master map using the Geo-map software. Densification of the detailed network by multiple angle-linear method. Determination of height of newly established points by trigonometric leveling method. All topics include the entire scope of work from the project, through measurement and numerical elaboration to the completion of the measurement operation.
49	Field Training in Engineering and Industrial Surveying	Learning a practical profession. Ability to perform precise geodetic measurements and their development in the field of engineering measurements. Learning to use electronic instruments in the field of measurement, registration and processing of measurement results. Organization and performance of measurements on engineering objects.