Type of programme: full-time bachelor's degree, 7-semesters with hours/week and ECTS

Field of education: Geoinformatics

No	Course	Plan	Sem. I				Sem. II				Sem. III				Sem. IV				Sem. V				Sem. VI				Sem. VII			
	l - lecture, e - exercices, p - project, E - exam		l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS
	General courses																													
1	Facultative class - Humanities, economic, social and law subjects																													
1a	Facultative class 1a - Intellectual property law	15					1			1																				
1b	Facultative class 1b - Entrepreneurship and Design Thinking	15					1			1																				
1c	Facultative class 1c - Law (civil, administrative, economic)	30																	2			2								
1d	Legal Regulations on Geoinformation (HES)	30																					2			2				
2	Foreign language (selected one) /E (B2)	180						4		4		4		4		4		4												
3	Sport class	90		2		0		2		0		2		0																
	SUM	**360**	**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																													
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	Discrete mathematics	30									1	1		3																
5	Physics /E	105	2	1		4	2		2	4																				
6	Fundamentals of Information Technology	45	1	2		3																								
7	Introduction to Computer Graphics with Elements of Descriptive	30		2		3																								
8	Algorithms and Data Structures	30	1	1		2																								
9	Programming Languages and Techniques /E	90	1	2		3	1	2		4																				
10	Data Bases	30					1		1	2																				
11	Block A - Facultative class of limited choice (Architecture of Information Systems / Internet Technologies)	30					1	1		2																				
12	Block B - Facultative class of limited choice /E (Software Engineering / Telecommunications technologies)	30																					1	1		2				
	SUM	**615**	**8**	**12**	**0**	**24**	**8**	**6**	**3**	**19**	**1**	**1**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**	**0**	**0**	**0**	**0**
	Profile courses																													
13	Introduction to Geomatics	15	1			1																								
14	Spatial Data Infrastructure	15									1			1																
15	Spatial Data Bases and Models /E	60									2		2	5																
16	Computational Geometry	45									1	2		4																
17	GIS Software	45									1		2	4																
18	Spatial Information Standards /E	30									1	1		3																
19	Programming of Geoinformation Applications	120													2		2	5	1		3	5								
20	3D Computer Graphics / E	30													1	1		2												
21	Spatial Data Internet Publication	30																	1	1		2								
22	Spatial Analyses	45																	1		2	3								
23	Topographic Data Bases	30																					1		1	2				
24	Block C - Facultative class of limited choice (Spatial Data Formats/3D Data Standards and Conversion)	30													1	1		2												
25	Block D - Facultative class of limited choice (GIS Thematic Applications / GIS Mapping Applications)	45													1		2	4												
26	Block E - Facultative class of limited choice (Programming of Mobile Geoinformation Applications / Location-based and navigation application) /E	45																					1		2	3				
27	Block F - Facultative class of limited choice (Multimedia and DTP / Introduction to Digital Image Processing) /E	45																					1		2	3				
28	Design of Geoinformation Systems	30																							2	3				
29	Management of IT Projects	30																					2			2				
30	Basics of Surveying /E	120	2	2		5	2		2	5																				
31	Electronic Measurement Techniques in Geodesy	30									1		1	3																
32	Selected Issues of Higher Geodesy	45									2		1	3																
33	Principles of Map Projections	30													1		1	2												
34	Fundamentals of Cartographic Visualization /E	45													1		2	4												
35	Satellite Navigation Systems /E	60													2		2	5												
36	Fundamentals of Photogrammetry	30													1		1	2												
37	Photogrammetric Measurement Technologies /E	90																	2		2	5	1		1	2				
38	Remote Sensing	60																	1	1		2	1		1	3				
39	Introduction to Spatial Development	30																	2			2								
40	Spatial Planning	15																	1			1								
41	IT Cadastre Systems /E	60																	2	2		5								
42	Geodetic Measurement and Management Systems	30																			2	2								
43	Facultative class 2	15																	1			1								
44	Facultative class 3	30																						2		3				
45	Facultative class 4	15																					1			1				
46	Facultative class 5	15																					1			1				
47	Facultative class 6	15																					1			1				
48	Internships (12 weeks)																													15
49	Diploma Seminar	30																						2		2				
50	Diploma Thesis																													15
	SUM	**1455**	**3**	**2**	**0**	**6**	**2**	**0**	**2**	**5**	**9**	**3**	**6**	**23**	**10**	**2**	**10**	**26**	**12**	**4**	**9**	**28**	**10**	**4**	**9**	**26**	**0**	**0**	**0**	**30**
	TOTAL		11	16	0	30	12	12	5	30	10	10	6	30	10	6	10	30	14	4	9	30	13	5	9	30	0	0	0	30

Courses descriptions

	General courses including humanities and economics, and major for the field of education	
	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.
	Legal Regulations on Geoinformation (HES)	Copyright - general issues, division, scope of protection, Transfer of copyrights – method of transfer, licenses, Limitation of protection of copyrights, Protection of computer programs, Public domain, Free and open source software – legal issues, open and closed icence, Public information – concept, object, providing, Data, information, knowledge – concept and mutual relation, Spatial data, spatial data sets, metadata and spatial information - concept and mutual relation, Spatial information infrastructure - spatial data services, interoperability of spatial data sets and the principles of its ensuring, Spatial data service networks - creation, inclusion in the network, rules of access to services and its limitation, Databases - the concept and types of databases, principles of their protection, Personal data protection - GDPR, principles and grounds for processing personal data, information provided to persons whose data is processed, Rights of persons whose data is processed and reporting data protection breaches.
	Basic courses	
	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, those associated with matrix diagonalization associated with the eigenvalue problem and those following from the orthogonalization procedures.
	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: introduction to the theory of probability; random variables with discrete and continuous dis-tribution; multidimensional random variables; estimation of statistical parameters – ex-pected value, variance, standard deviation and correlation coefficient, confidence intervals of the estimated values; verification of statistical hypotheses, particularly those concerning the expected value, variance, standard deviation and correlation coefficient; propagation of the vector of expected values and the covariance matrix associated with transformation of the random vector.
	Fundamentals of Information Technology	Applications of the binary system in computer computing. Computer construction. CPU operation. Computer memory. Operating systems. Interprocess communication. File system. Basics of computer networks. Converting between number systems and acting on binary numbers. Operating system shell: basic commands and file operations. Operating system shell: monitoring the state of the system. Operating system shell: searching, comparing, and filtering text data, regular expressions. project: automation of work using shell scripts. Tools for automatic software building. 7Version control systems. project: Multithreaded calculations. Configure the computer to work in the network. Network Connection Diagnostics. Querying and configuring the DNS server and querying the WHOIS system.

	Introduction to Computer Graphics with Elements of Descriptive	Introduction to working in CAD environment. Design principles in CAD. Project preparation, environment setting (units of measure, coordinates, boundaries, etc.). AutoCAD 2D Drawing and Editing Tools. Layers, projection solid on the surface of the projector, cross-sections. Blocks (building block library). 3D modeling. Editing tools, solid penetration. Transform a 2D object into a 3D object - design. Collaborate with other editors (import, export), copy and print the project Raster Graphics Tile. Basic raster description (color vision, color spaces, channels, recording formats, compression, resolution). The effect of saving and compression format on image quality and size. Single image retouch (contrast, saturation, histogram balancing). Modify a single image (masks, cut, crop, paths, nodes). Working with multiple images - photomontage. Raster image tracing.
	Algorithms and Data Structures	Basic concepts: algorithms, block diagrams, techniques for creating algorithms, examples of iterative and recursive algorithms. The divide-and-conquer technique, binary search. Computational complexity of algorithms: time and memory; pessimistic, optimistic and expected. Big Oh notation, examples of computational complexity of algorithms. Basic data structures: variables, pointers, records, arrays and lists. Abstract data structures: stack, queue and priority queue. Union-find algorithm. Elementary sorting algorithms: bubble sort, selection sort, insertion sort. Shell sort algorithm, merge sort algorithm recursive and bottom-up. Quick sort and 3-way quick sort algorithms. Sorting records, stable sort, partially sorted array, hybrid sort, system sort. Binary search trees, operations on BST. Balancing BST - DSW algorithm, self-organizing trees: splay, AVL and red-black, hash tables, association array.
	Programming Languages and Techniques	Introduction to software engineering, basic concepts and definitions. Projects and processes, software development process. incremental, spiral, agile. Requirements engineering, functional, non-functional and domain requirements. Gathering requirements, ANSI/IEEE 830 standard. Introduction to UML, Use Case diagrams. Architecture of Information Systems, Component diagrams, Package diagrams. Architectural patterns: multitier architecture, repository, client-server, MVC passive and active. Activity diagrams and sequence diagrams. Object-oriented modelling, objects and classes, abstraction, encapsulation, polymorphism, inheritance, associations between classes; class diagrams and object diagrams. Design patterns: Singleton, Adapter, Facade, Observer. Design patterns: Strategy, Chain of responsibility, Factory method, Abstract Factory, Bridge. Software quality, ISO 9126 standard. Software testing, unit tests, integration tests, system tests, acceptance tests, static and dynamic testing, active and passive testing, white-box, black-box and grey-box testing. Software development paradigms, weak and strong typing, static
	Data Bases	Database vs Database Management System. Databases classification. Relational data model (relationships normalization, primary and foreign keys, implementation of 1:1,1:N, N:M relationships, integrity constraints, indexing). SQL language. Object data model. Basics of informatics systems and databases design (including UML class diagrams). Base concepts of Spatial Databases. Databases in the management of enterprises and institutions. Data warehouses. Big Data management. Database management systems review (Commercial and Open Source software). Designing database exercises in two different database management systems. One of projects uses pro RDBMS. Exercises in practice SQL using two different RDBMS. Creating a database project
		Profile courses
	Introduction to Geomatics	BLOCK I Basic concepts in geomatics. Introduction. From surveying to spatial information infrastructures. Basic definitions - geomatics, geoinformatics, computer science, geodesy and cartography, geoinformation, GIS, geospatial engineering, spatial information, geographic information, spatial data, geographic data, spatial information infrastructure). The relationship between cartography, geoinformatics, geodesy, cartography, surveying and other geomatics related disciplines. Geomatics within national smart specializations - priority areas for technology development. BLOCK II (Spatial information infrastructure). Introduction to spatial information infrastructure. Data management at national and regional level. Outline of modern techniques for spatial data extraction. Introduction to the most important legal regulations concerning geomatics, especially geodesy and cartography. BLOCK III (Data analysis and knowledge acquisition). Review of spatial data processing and analysis methods based on computer, mathematical and statistical methods. The role and application of spatial data in the development of various fields of technology and science, and the development of an information society.
	Spatial Data Infrastructure	Spatial data infrastructure (SDI), Spatial information infrastructure (IIP), INSPIRE, standards and norms for collecting and sharing spatial information and metadata, INSPIRE implementation guidelines, the role and functions of geoportals. spatial data themes implemented under IIP in Poland. Characteristics of official spatial data in Poland, organizational and legal aspects related to the keeping of official registers (the Geodetic and Cartographic Act, the Act on spatial information infrastructure, the Act on public statistics). Large-scale numerical (basic) map as a basic SIT element. Legal bases to keep your data up to date. Technical and legal aspects of the implementation of geodetic works. Surveying works as a resource update mechanism. Providing data from PZGiK. Data Sharing Fees. Legal aspects of data sharing. Influence of the INSPIRE directive on sharing geodetic data in the Internet. The current state and future in the field of spatial data
	Spatial Data Bases and Models	Specifics of spatial data management. Spatial data description models (vector, raster, TIN, GRID and others). Geometric data types. Spatial relationship models. Fundamentals of spatial indexing. Fundamentals of networks modeling. Introduction to Linear Reference Systems. Using SQL language with spatial operators. Methods of recording spatial data in selected GIS programs (e.g. ArcGIS, Geomedia) and spatial databases (e.g. Oracle Spatial). Examples of standardized conceptual models of spatial databases (e.g. from Polish national spatial information infrastructures). Spatial database design and implementation. Introduction to selected spatial database environments (e.g. Oracle Spatial, PostGIS). Practicing using SQL query language extended by spatial operators in selected software.
	Computational Geometry	Introductory concepts. Historical outline of computational geometry. Basic definitions. Basic data structures used to solve geometric problems. Characteristics and notation of geometric objects. Properties and use of vector product in computational geometry. Approximation of objects by bounding rectangles. The problem of intersection of lines and segments. Finding pairs in a set of segments that intersect. Investigation of the location of a point inside a polygon. Methods of solving the task. Special cases. Creating a convex envelope of a set of points. Methods of solving the task. Generalization of the shape of geometric objects. The problem of intersection of polygons. The problem of triangulation of a set of points. Delaunay triangulation. Voronoi diagram and its use. Development of a computer program to check the position of a point inside a polygon. Development of a computer program to determine the convex envelope of a set of points. Development of a program to triangulate a set of points.
	GIS Software	Software as off-the-shelf or Custom Low-Code Development product. COTS software: advantages and disadvantages. NDI software: advantages and disadvantages. Free and open software. History of GIS software development. The functionality of GIS programs. Overview of commercially available GIS software. Free and open software: types of licenses. Introduction to free and open software (QGIS). GIS in the cloud. Examples of the practical application of GIS in the cloud. Web-based mapping software - OpenLayers, Leaflet, MapTiler, GeoServer, ESRI. Lab Exercises: build on the basic ArcMap, QGIS, and MapInfo thematic maps. To gain some experience with incorporating raster datasets into maps: access orthophoto, satellite data, and DEM with the help of several GIS programs. Finally, convert some of your finished maps into Portable Document Format (PDF) files, a format that facilitates the electronic distribution of your work. Designing and launching a WMS website using Geoserver software and editing the WMS website using OpenLayers/Leaflet technology.
	Spatial Information Standards /E	The basic concepts of standards (ISO, OGC, W3C, OMG). Objectives and tasks of ISO standardization. Process of ISO standardization. The subject, structure and organization of standardization in spatial information. Basics of UML, XML and MDA. Selected issues from the ISO 19100 series standards: reference model (PN-EN ISO 19101); concpetual schema language (ISO 19103); spatial schema (PN-EN ISO 19107); rules for application schema (PN-EN ISO 19109);-methodology for feature cataloguing (PN-EN ISO 19110); web map server interface (PN-EN ISO 19128); metadata (PN-EN ISO 19115); geography markup language (PN-EN ISO 19136); data quality (ISO 19157). Project: Implementation of a set of abstract tests for selected ISO standards. Development of the UML application schema on a given topic, integrated with the ISO 19100 series with metadata.
	Programming of Geoinformation Applications	Introduction to Java environment: source program, compiler, virtual machine, API libraries, JDK configuration, documentation, Java Tutorial, packages, package and source file management. Console program. Applications. Java language overview: basic program elements, Java type system, built-in types, constants, variables, operators and expressions, structural and control instructions - comparison with C++. Block, scope of name. Handling exceptions, try-catch-finally statement. Object-oriented programming: classes and objects, class definition, object creation, object life cycle. Defining methods, overloading, signatures, abstract and synchronized methods. Working with arrays. Inheritance and polymorphism. Interfaces. Access control system. Basics of programming and design patterns. Overview of basic classes and packages: java.lang package, Object class, envelope types, String class; System, Runtime, Runnable, Thread classes, Throwable class and its derivatives. java.io package, I/O system, streams, channels. java.util package, collections. Functional programming. Graphic and event programming: visual components, their layouts, interactive application, MVC model, graphic interface. Javax.swing package, AWT — Swing relationship. Delegation model of event handling, event class. Graphical operations. Simple image processing, animation. Multithreaded programming: concurrency, reacting to events, threads. Thread formation, main thread. Thread states, thread priorities, race, deadlock, livelock, thread synchronization; synchronized methods, monitors. java.util.concurrent package. Network programming: TCP socket, UDP packet, communication protocol, client-server model. Other JDK packages: review of standard packages from the applicational point of view: distributed programming, relational databases programming, component programming. Project: Development of geoinformatics applications to automate processes in GIS software (generalization, export/import, spatial analysis). Development of web-based geoinformatics applications for presentation and analysis of spatial data. Creating applications with specific software libraries (e.g. Google Map API) using Google map services and OGC map services (e.g. WMS, WFS). Introduction to Python. The Git version control system. Laboratories: Development of an application for geospatial data analysis in Python. Development of models of selected spatial data in NoSQL databases. Development of applications for processing spatial data with the use of NoSQL databases. Integration of developed solutions with GIS software.
	3D Computer Graphics	Reminder of 3D mathematical fundamentals - rotations, transformations, matrices. Basics of geometry representation of three-dimensional objects (points, lines, grids). Rendering (lighting models, texturing, depth maps, camera parameters). Rendering and Environment Engines (Unity, Unreal etc). OpenGL Programming Basics. Advanced GPU programming (graphics, rendering pipeline, lists, buffers). 3D modeling and visualization software. Exercises: Proposed working environment: Lazarus IDE. Graphic Context Building and 3D Scene Presentation. Modeling using elementary surfaces - creating a simple 3D model with animation elements. Mesh modeling - creating a realistic model of terrain with topographic objects. Visualization including texturing, lighting, fog, and observer movement.
	Spatial Data Internet Publication	Internet publications: the specificity of sharing spatial and multimedia data on the Internet, tools and methods of publishing cartographic presentations, compilation of independent publications. Principles of website editing, designing websites (webmastering), issues of the usability of internet publications, W3C standards. Classification of spatial data services (web services): browsing, searching, integrating. OGC standards. The functionality and configuration of the map server environment. Designing a geoinformation service (WebGIS): database organization, presentation editing, configuration of the sharing service, user application design.
	Spatial Analyses	Introduction to spatial analysis, basic concepts, definitions. The adopted data model (raster, vector) and the specificity and scope of analyzes, operators and functions of spatial analyzes in a raster and vector environment; review of selected issues. Multi-criteria analyzes. Analysis of land suitability for a specific purpose, economic activity, etc. Methodology of analyzes with the use of raster and vector data, decision criteria, types of criteria, selection of an analysis method, normalization and evaluation of criteria, weighting, methods of combining responses to criteria. Overview of practical applications in the field of land suitability analyzes. Usefulness of land for construction. Methodology of solving tasks in the field of land suitability analyzes in the case of conflict goals. Multi-criteria comparative analysis. Designing optimal connections on a specific surface area; variability / stability of properties depending on the direction (anisotropy / isotropy), 'distance' weighted by costs, costs taking into account the specific characteristics of the terrain. Relative and cumulative cost areas. Analyzes using DTM data and the land cover model (3D), examples of applications. Modeling of the phenomenon of erosion; geometric model of the runoff, USLE model. Topology, poplar model, advantages in spatial analyzes. Study of changes, methods of time changes analysis. Network analyzes, network models, geometric and topological networks, basic types of network analyzes, application overview. Examples of the use of spatial analysis in the decision-making process. Decision support systems. Expert systems. Assessment of the quality of the results of spatial analyzes. The quality of input data and the accuracy of the results of spatial analyzes, data uncertainty, risk level assessment.
	Topographic Data Bases	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 topogrphic data acqusition. Features of Polish contemporary 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. cyvil and military topographic databases. Database managemenst system of BDOT10k, rules of its updating. Projects: Structure of BDOT and analysis of data. Selection with SQL and spatial operators, using of relations, selection by attributes, cartographic visualization of results. Updating the topographic databes (BDOT) using ortophotomap by WMS - exemlpary objects. Comparsion of recources of two reference databases - BDOT and VMapL2 - in chosen ranges. Review of changes in conceptual model of Polish topographic database (TD, BDOT) using chosen
	Design of Geoinformation Systems	Implementation of a prototype of a geoinformation system, program, sets of programs, libraries or procedures along with documentation carrying out a complex engineering task consisting in the automation of the process of acquiring, processing and sharing spatial information or in automating, improving, optimizing the operation of instruments and systems that serve these processes. The designed systems should use knowledge from one or more of the following specialties / areas: - basic geodetic measurements, photogrammetry, remote sensing, cartography, navigation, engineering and industrial surveying, geodesy and geodetic astronomy, cadastre and real estate management, spatial management.
	Management of IT Projects	Specifics and types of IT projects. Methods of managing IT projects. Risk and changes in the project. Tools and technologies supporting project management. Team work. Group work tools. The role of the project manager. Models of work and communication. Reasons for failures of IT projects. IT product management. Introduction to the Prince2 methodology. Selected legal aspects of the activity of IT companies.
	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.
	Electronic Measurement Techniques in Geodesy	Electromagnetic waves and the range of the wave spectrum used in surveying. Fundamentals of metrology and the definition of units. Phase EDM. Pulse EDM and determining the necessary accuracy of time measurement. GNSS satellite measurements. Propagation of electromagnetic waves. Measurement of meteorological conditions, working formulas for the atmospheric correction. Distance measurement errors. Electronic theodolites and methods of electronic angle measurement. Electronic total stations. The use of lasers in geodesy. The use of the interference in geodesy. The idea of operation of laser scanners. Digital levels - the principle of building a code level . Transmission of measurement data to a computer (RS232). Tasks for calculating the atmospheric correction to the measured length with a EDM. Development of a program to determine the influence of the environment on the measurement with an electromagnetic meter. Development of a program for receiving data recorded with geodetic instruments.
	Selected Issues of Higher Geodesy	Physical geodesy elements: definition of the gravity vector and gravity potential. Shape of the main geometrical elements of the gravity field. Geoid and quasi-geoid modelling with using gravimetric data. Height systems and definition of the height as the geopotential feature. Structure and division of geodetic data and rules for using geodetic data systems databases; GGOS data sources, including ITRF, IGS, GGP, AGrav, WGM, ICGEM, BGI, ISG etc. Problems and advantages of using different techniques and products of GGOS. Project: Elements of spherical trigonometry in astronomic triangle and geometry of the ellipsoid: ellipsoid parameters and basic relationships between them, geodetic coordinates, conversions, geodetic problem solution on the ellipsoid: direct Kivioji method, inverse Vincenty method. Conversion of geodetic coordinates to mapping planar coordinate systems; reductions of observations to the mapping plane. Transformations between spatial geodetic coordinate frames. Height computations base on the geopotential feature. Satellite levelling – using of obligatory quasi-geoid models to conversion ellipsoidal height to normal or orthometric height system. Creation of the regional local analytical quasi-geoid models by least square method.

	Principles of Map Projections	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.
	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.
	Satellite Navigation Systems	Lecture: theory of the motion of artificial satellites: Keplerian and perturbed motion; elements of the orbit; types of orbits; equation of motion; integration of equations of motion; orbit equation; movement in circular and elliptical orbits; Kepler's equation; orbital and terrestrial coordinate frames of the satellites; satellites skyplots; geostationary satellite; perturbed satellite motion; division of perturbing forces; osculatory elements. GNSS measurements: the architecture of GNSS systems; GNSS satellite signal analysis; GNSS receivers and antennas; code and carrier-phase equation of pseudorange, initialization of GPS measurements; absolute and relative (differential) measurements. GNSS measurement technologies: static, fast static, kinematic, RTK and DGPS techniques; GPS measurement errors; creation of GPS observation differences, linear combinations of carrier-phase observations; advantages and disadvantages of measurements based on the global positioning system GPS. Other existing and planned global satellite navigation systems: GLONASS, Compass and Galileo systems; system similarities and differences; the benefits of using the systems together. Overview of regional QZSS, IRNSS GAGAN, NIGCOMSAT etc. Satellite and ground support systems, including the ASG-EUPOS system. GNSS in GIS and navigation applications, GPS / INS integration. Projects: tasks in the theory of the motion of artificial satellites of the Earth; determination of the horizontal and geocentric coordinates of the GPS satellite based on the broadcast ephemeris; calculation of DOP coefficients; calculating the position of the receiver - navigation solution; planning, preparation and field measurement with RTK / RTN technology; ASG-EUPOS services - rules of use and data formats; Kalman filter in INS / GPS systems.
	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.
	Photogrammetric Measurement Technologies	Stereoplotter processing of the stereogram of analog aerial photos. Image Matching. Stereoscopic observations and stereoscopic measurement. Basics of Image Matching. Image Matching strategy. Digital photogrammetric workstation - DPW. Aerotriangulation - definition, introductory remarks. 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). General characteristics of laser beam measurement systems. Terrestrial Laser Scanning measurement principle. Point cloud filtering and orientation methodologies and algorithms. point cloud recording formats. selected software and libraries of algorithms for TLS data processing. The issue of integration of multi-source photogrammetric data (ALS, TLS, images). Project exercises: discussion and demonstration of algorithms used in Z+F LaserControl and LupoScan software. demonstration of how to display and save spatial point clouds (CloudCompare). Demonstration of how to display and save point clouds from ALS (ArcGIS and CloudCompare). Execution of TLS data transformation application to raster form. Perform TLS point cloud orientation application using Target-Based method. Use the 3D Toolkit library for ICP and SLAM6D point cloud orientation. Use of RANSAC algorithm from 3D Toolkit library for ALS and TLS data processing.
	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. 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 source for GIS. Exercises: Comparison of the quality of scanned analog and digital photos. Object recognition and identification using panchromatic and near-infrared images. Shades of gray and other distinguishing features of objects. Searching for characteristics describing different classes of objects. RGB and color infrared images, multispectral images - the possibility of recognizing various objects and their properties. development of an algorithm for the detection of selected objects based on multispectral satellite images. Lecture. General introduction to digital satellite image processing, overview of the basic processing steps. The role of the histogram, improving the quality of images using the linear function and non-linear functions, Color compositions, creation and practical use, Multichannel transformations, analysis of the vegetation state with the use of vegetation indicators. Combining panchromatic and multispectral data (pansharpening). Satellite image filtering. Digital classification of land cover forms in a supervised approach. Assessment of the accuracy of the thematic digital classification of land cover forms. Object-oriented approach to the analysis of satellite images.
	Introduction to Spatial Development	Basics of spatial planning. Multidisciplinary approach to spatial management. Concepts: spatial economy, town planning, region, city, urbanization and suburbanization. The importance of city-forming factors. Functions of the city in terms of urban planning. Athens Charter, Leipzig Charter. The role of the city in the modern economy. Problems of contemporary cities. Sustainable development of cities. Le Corbusier and his visions. The city center and its features. Problems of downtown areas and their transformation. Public space - Shaping and transforming public spaces in the spatial structure of cities. Examples from home and abroad. General outline of the history of urban development. Genesis, conditions and historical, economic, social and political context. Antiquity: Hippodamaic network, functional and spatial significance of Roman military camps. Middle Ages - the formation of city rights, the development of crafts and trade, the rise of defensive cities. Modern times - the influence of great geographical discoveries and the industrial revolution on the development of cities. The importance of trade routes in the development of cities. Formation of great ports and industrial cities. Modern times - theoretical foundations of city building, compositions of baroque assumptions. Recent times: transformations of cities in the second half of the 19th century. Impact of technological and industrial development on the quality of life in the city. Creation of the theoretical foundations of city building: garden cities and industrial city. Composition as a way of shaping the city. Elements of the urban composition. The main elements of the city's spatial structure affecting the observer. Basic types and examples of urban compositions. The role of composition in the process of urbanization. Cultural heritage and identity of the place. Valorization in urban analysis. The importance of historical continuity and the identity of a place in spatial projects and shaping new urban structures. Socio-cultural aspects. Sociology of cities - general issues. Social space in the city. Sociological aspects of the city structure. Issues of local communities. The problem of gentrification in the city and the revitalization process. Social differences, urban conflicts and polarization. The concept of revitalization and social participation. Social problems in the process of spatial planning. Social and spatial structure of cities. The importance of urban inventory and analysis of conditions. Assessment of the potential of the area for the purposes of spatial planning. Contemporary urban instruments. Urban plan - elements of the method. Concepts of, among others: the Local Spatial Development Plan and the Study of the Conditions and Directions of Development. The main concepts of autonomous vehicles in the city. Examples of implementations of autonomous vehicles for public use. Presentation of the conditions and assumptions of a specific concept of an urban design with the use of AV technology. An introduction to the issues of urban design using the Design thinking and Project Based Learning methods. Development of conceptual urban design issues with the introduction of autonomous vehicles with infrastructure - graphic design. Transformation of urban areas with the use of AV technology. Urban design including the introduction of autonomous vehicles with infrastructure - graphic design. Public presentation of a conceptual, schematic
	Spatial Planning	The spatial planning system in Poland. Planning documents prepared at the local level. Procedures for preparing a study of the conditions and directions of spatial development and a local spatial development plan. Social participation in the process of preparing planning documents. 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. Planning situation of communes in Poland. Urban and Architectural Commission. Decision on building conditions. Decision on the location of a public purpose investment. Economic analysis of the implementation of the local spatial development plan.
	IT Cadastre Systems	Lecture: Cadastre – its role and tasks in the economy. Legal basics of cadastre functioning. Organisational structures of cadastre functioning. Cadastral division of the country: registered unit, cadastral district, parcel. Collections of information on cadastral objects, i.e. parcels, buildings, and premises. Subject data in the cadastre. Land use classification. Cadastral map. Concept of real estate. Land register system – development of a land register, scope of recorded data. Connections of the cadastre with land register and the fiscal cadastre system, data exchange between the systems. Integrated System of Information on Real Estate. Cadastral solutions in selected EU countries. 3D cadastre. Practical classes: Practical use of the existing information systems in which the cadastre is run. Establishment of a cadastral data base for a selected surveying district in the software. Functions of data import and export. Development of the descriptive part of the cadastre for a selected surveying district and preparation of basic reports. Verification of the compliance of land use classes in the cadastral data base with specification of the concept model of cadastral data. Verification of the compliance of attributes of boundary marks and plots with source documentation. Development of a data base of register of real estate prices and values. Statistical analyses conducted on data on real estate.
	Geodetic Measurement and Management Systems	Construction and classification of the geodetic measuring systems applied for deformation monitoring. Familiarizing with the basic elements of measuring systems for selected manufacturers of the geodetic instruments. Measuring systems for typical building constructions – system configuration, main functions, and their applications. Means of communication between measuring system elements. Automated total station as a basic element of various measuring systems. Measuring systems based on the build-in instrument's software. Remote measuring systems for industrial applications - functions and classification. The measuring system using angular intersections. TC-calc, as an example of the measuring system using the polar method. Devices for automatic measurement of tilts and their usage in monitoring systems. General remarks of integrated systems for conducting automated monitoring. General rules of system elements location and organization of data flow. Methods of presentation of automated measurements results.
	Diploma Seminar	Principles of writing an engineering thesis, guidelines for the thesis exam, presentations of the scope and progress of the thesis, practicing the ability to present the results of their work