Second-cycle studies programme with hours/week in three semesters [15 weeks]

Field of education: Geodesy and Cartography, specialization Cartography and GIS

No.	Course	Sem. I				Sem. II				Sem. III			
	l - lecture, e - exercices, p - projeckt, E - exam	l	e	p	ECTS	l	e	p	ECTS	l	e	p	ECTS
	General courses												
1	Selected issues of economy law	1			1								
2	Human rights					1			2				
3	Geodetic and Cartographic Law									1	1		2
4	Specialist foreign language										2		1
5	Mathematics		2		3								
6	Selected Topics of Mathematics and Numerical Methods /E	1	2		4								
7	Geophysics	1	1		2								
8	Selected Topics of Physical Geodesy and Geodynamics			1	2								
9	Digital image processing			2	2								
	Profiled courses												
10	Standards in Geographic Information	1			2								
11	Spatial Data Infrastructure	1			2								
12	Cartographic Modelling /E	1		2	3								
13	Photogrammetric Technologies /E	2		2	4								
14	Geostatistics	1		1	2								
15	GIS Technologies	1		1	3								
16	Facultative class 1					1		1	2				
17	Facultative class 2					2			1				
18	Facultative class 3					2			1				
19	Facultative class 4					2			1				
	Specialization courses												
17	Field exercises in cartography						1		2				
18	Digital Systems of Map Production					1		1	2				
19	Generalisation of Geographic Information /E					1		1	3				
20	Computer Graphics in Cartography					1		2	3				
21	Mathematical Cartography					1		1	3				
22	Thematic Cartography /E					1		1	3				
23	Cartographic 3D Models					1		2	3				
24	Spatial Databases Design /E					1		2	4				
25	Mobile Cartography									1		1	2
26	Diploma Seminar										2		1
27	Selected Topics of Geostatistics									1		1	2
28	Advanced Geographic Analyses									1		2	2
	TOTAL	10	5	9	30	15	1	11	30	4	5	4	10

Courses descriptions

	General courses	
	Selected issues of economy law	1. Basic information on economic law 2. Sources of law, including the economic law 3. Legal entities. an individual and a legal person, methods of their creation and their legal capacity. 4. The principles of representation of legal persons. 5. Basics principles of obligation. Contracts as a source of obligations. The principle of freedom of contracts. Modes of concluding a contract, in particular in the economy. 6. The principles of fulfillment of contractual obligations. Consequences of non-performance or improper performance of the contract. 7. Taking up and running a business. The concept of the entrepreneur. Forms of runnning and requirements for starting a business. 8. Economic freedom and its limitation 9. Registration of running of an individual entrepreneur in the Central Register of Economic Activity, Polish Classification of Economic Activity 10. Company law. Principles of establishing companies. Register of Entrepreneurs of the National Court Register 11. Partnerships and capital companies – main features

	Geodetic and Cartographic Law	Lecture: Tasks of the organs of the geodetic and cartographic service. State geodetic and cartographic repository – management, sharing, fees, licenses. Submission of geodetic and cartographic works. Coordination of utilities network projects. Protection of geodetic controls. Geodetic works in closed areas. Technical standards applicable in surveying. Rules for completing technical reports. Professional qualifications in the field of geodesy and cartography. Exercises: Preparation of a geodetic work application. Preparation of a fee calculation document for materials for the submitted geodetic work, drawing up a license for the above-mentioned geodetic and cartographic materials. Preparation of a technical report for the submitted work and the content of the technical report for a specific assortment of surveying work. Preparation of an application for authentication of geodetic materials resulting from surveying work. Preparation of a notice of completed surveying work. Preparation of an application for coordination of the utilities network project.
	Specialist foreign language	Achieving the B2+ level of knowledge of a foreign language by expanding the specialist vocabulary related to geodesy and cartography and improving other skills that will enable students to communicate freely in a foreign language, prepare effective presentations and write an abstract of a master's thesis, report or texts in a foreign language useful in their professional work.
	Mathematics	Functions of complex variable: function derivative, Cauchy-Riemann equations, holomorfic function. Integration of complex function, Cauchy integral theorem, Cauchy integral formula, Laurent series, residual of the complex function and its application for the computation of integrals. Basic equations of mathematical physics. Partial differential equations of the first and second order and their classification. Differential equations of the string and of the thermal conductivity. Fourier method of the separation of variables. Integration and ultra-tight (deep) integration.
	Selected Topics of Mathematics and Numerical Methods /E	The main purpose of the course is to give students theoretical and practical knowledge on the selected methods of random signals analysis. The course will present mathematical background and describe algorithms of empirical data analysis, both in the time and frequency domain. The course will begin with a short introduction to the theory of probability, random variables and their parameters. Next, given is description of the random signals with special attention paid to the properties of stationarity and ergodicity. The basic characteristics of the signals are introduced: mean value and variance, probability density, autocorrelation and power spectral density (PSD) functions, then the joint characteristics: joint probability density, cross correlation and the cross power spectral density (CPSD). The data analysis algorithms will include the classical methods, based on the digital Fourier transform, and the parametric methods focusing on the autoregressive (AR) modeling of time series. The last part of the course is devoted to the application of the linear Kalman filter to the time domain analysis of discrete data. It begins with definition of the linear dynamical system using the state-space formulation, then the filtering equations are derived. The project part of the course includes application of the computer programs for analysis of empirical data.
	Geophysics	The purpose of this course is to give the students a basic knowledge on the folowing subjects: The Earth as a planet. Internal structure of the Earth. Isostasy – postglacial rebound. Plate tectonics: oceanic rifts, subduction zones, orogens, transform boundary. Rheology. Seismology: seismic waves, seismic wave propagation, Richter scale. Earth's magnetic field: parameters, units, constituents, geodynamo hypothesis. Magnetic surveying: magnetic anomalies. Geomagnetic poles, equator and coordinates (calculation of). Paleomagnetism, polarity reversals. Magnetosphere, magnetic storms and solar activity. Hydrological cycle, physical properties (density, optical, acoustic) of oceanic water. Physical oceanography: thermocline, waves, currents, deep-water circulation, oceanic tides. Basic of fluid dynamics. Particular attention is paid to the interactions between geophysics and geodesy. That includes those geophysical theories and models which are used in geodetic practice, as well as the geodetic observations and models which can support geophysical research.

	Selected Topics of Physical Geodesy and Geodynamics	Gravimetric measurements - construction of a gravimeter, preparation for measurement (calibration, adjustment) - calculation exercise: determination of the gravimetric factor from measurements on a calibration basis. Gravimetric measurements - Development of a gravimetric measurement with the calculation of the tidal correction - calculation exercise: preparation of the results of a gravimetric span measurements with relative method. Gravimetric measurements - development of measurement results: calculation of the field correction, calculation of reductions and gravimetric anomalies - calculation exercise: preparation of a map of free air anomalies and the full Bouguer anomaly.
		Tidal deformations - determination of the deformation of the earth's crust caused by tidal phenomena, static and dynamic tidal model - computational exercise: determination of the deformation of the earth's crust in the neu system for a specific point in a given period. Non-tidal deformations - determination of deformations caused by non-tidal phenomena (atmosphere, hydrology or anthropogenic and local factors) - computational exercise: determination of the Earth's crust deformation in the neu system for a specific point. Implementation of the EVRF2007 system - determination of the increments of geopotential number with the use of real gravimetric measurements and geopotential models - accuracy analysis - computational exercise: determining the increments of geopotential features for a selected leveling line, reduction to zero tide. The phenomenon of isostasy and its importance for the implementation of the geodetic network - computational exercise: modeling of the isostatic effect on the basis of the GNSS time series (Fennoscandia). Gravity field of simple geometric solids - elements of geophysical interpretation - computational exercise: modeling of gravity field anomalies resulting from anomalies of subsurface formations. Elements of the gravity field in connecting the natural (related to the plumb line) and geodetic (related to the normal line) coordinate system - computational exercise: reduction of traverse elements from the tacheometric system to the geodetic system related to the GNSS network.
	Digital image processing	1. Registration and development of a digital image 2. Digital image recording formats. 3. Lossy and lossless image compression methods. 4. Basics of image processing in Matlab (Computer Vision System Toolbox TM) 5. Basics of image processing in Python 6. Preprocessing (Matlab) and automatic image vectorization (ArcGIS) 7. Detection and analysis of text on images using the function Optical Character Recognition (OCR) 8. Clustering algorithms and the basics of machine learning for digital image classification. 9. Contextual processing: removing noise from an image through selected low-pass filters and detection characteristic elements of the image through high pass filters 10. Basics of mathematical morphology. 11. Basics of image texture analysis: fractal analysis, GLCM, granulometric analysis.
Profiled courses		
	Standards in Geographic Information	Lectures: 1. Concepts of standard and norms. Objectives and tasks of standardization. 2. The subject, structure, and organization of standardization in GI. OGC standards, ISO standards. 3. Standards formalism, ISO / TS 19103 specification - UML language and ISO 19109 - rules of application schemas. 4. Selected issues from the ISO 19100 series standards: - describing the position (ISO 19107, ISO 19125-1, ISO 19111 and ISO 19112); - temporal scheme (ISO 19108); - data quality (ISO 19157 and ISO 19158); - cataloging methodology (ISO 19110); - metadata (ISO 19115); - XML language - GML (ISO 19136 and ISO 19139). 5. Rules for the use of standards in specific applications.

	Spatial Data Infrastructure	Lectures: The rules of construction of european and national Spatial Data Infrastructure (SDI), the INSPIRE idea and choosen implementing documents. Standardization of geospatial data and services: ISO, CEN and PN standards. Basic definitions: feature class and collection, web service, harmonization, consistency, interoperability. Types and OGC standards of geospatial web services, its applications. Structure of SDI in Poland, the rules of building, the leading organisations. The law acts: transposition the UE law documents to Polish law Order, technical documents of GUGiK (Head Office of Geodesy and Cartography) concerning the reference and thematic databases and cartographic vizualizations. Recources of reference and themtatic data: conceptual models, standards, structures, LoDs, applications. Geoportal.gov.pl as a national SDI access point, its functionality. Metadata - definitions, standards, editors and problem of validation.
	Cartographic Modelling **/E**	Geographic data: DLM (digital landscape model) and DCM (digital cartogrphic model). Basics of the topographic data model. Properties of DLM and DCM models and their practical application. Conceptual models in topographic and thematic databases. Methods of analysis and generalization of geographic information. ISO 19100 series standards for modeling geographic information. Processing of geographic data. Spatial analyzes performed on vector and raster data. Surface modeling. Interpolation methods. TIN model, GRID model. Modeling of the relief surface. Network analyzes. Transformations of spatial data. Basic principles of using databases in cartography. Multimedia techniques in cartographic presentations: multimedia means of expression, software, formats of graphics, animations, sounds and video images, compression algorithms, principles of designing and implementing multimedia compositions. Basics of cartographic visualization of geographic information on the Internet. The specificity of sharing spatial and multimedia data on the Internet, rules of website editing, designing online cartographic publications, designing and configuring geoinformation services, issues of functionality of Internet publications.
	Photogrammetric Technologies **/E**	1. Demand for geoinformation data. The influence of solar lighting and the atmosphere on photographing the Earth's surface 2. Aerial digital camera. Large format cameras. Perspectives; Medium format cameras; Oblique cameras; Direct georeferencing (in flight) - advantages and limitations 3. The quality of present aerial photos. Lens, orthoscopy; Internal camera / photo orientation. Camera calibration. Calibration certificate. 4. The market for aerial photography. Country coverage with aerial photos. State archive of photos. 5. Satellite imaging in the optical range. VHRS systems. VHRS systems - spatial resolution; HRS systems - data openness policy. Constellations of nanosatellites – temporal resolution 6. Airborne laser scanning. Design of area imaging by ALS ; The form of the results, content, formats.

		Basics of data georeferencing (terrain control network, stages of georeferencing, quality indicators). Coloring the point cloud. Basic products. 7. Digital terrain models. Sources of elevation data. Types of models, structure, basic standardization parameters. Derivative products from DTM. Comparison of ALS point cloud and image data (image matching). Standards and state of country coverage with elevation models 8. Microwave interferometry (InSAR). Airborne and satellite InSAR systems. Single pass and repeat pass interferometry. Global coverage of altitude data from InSAR satellite systems. 9. Digital orthophotomap. Process of processing from aerial photos. Standardization parameters. Photo parameters vs. orthophoto parameters. True-ortho, "oblique" ortho. Orthorectification of satellite images. Orthophotomap as a source of topographic databases supply. Standards and state of country coverage with digital orthophotomap. 10. Terrestrial laser scanning. Mobile multisensory systems. Principle of operation of a terrestrial scanner and its application. The principle of integration of MMS and MLS sensors systems. Applications of MMS systems. 11. 3D modeling of buildings. Review and evaluation of data sources, multi-source data. 3D modeling standards, CityGML. 12. BSL. Low-altitude photogrammetry. Platforms. Legal regulations; Measurement systems, imaging systems; Elaboration of UAV data. Typical products; Imaging from UAV platforms vs. aerial photography from manned airplanes.
	Geostatistics	Lectures: 1. Introduction to spatial statistics, measurement scales. 2. Basic statistics - central tendency statistics, dispersion statistics, correlation coefficient. 3. Spatial autocorrelation and heterogeneity, the concept of a matrix of weights and the principle of selection. 4. Global and local measures of spatial autocorrelation. 5. Measures of spatial concentration - Lorenz curve and Gini index. 6. Regression and spatial regression - basic concepts and stages of model construction. 7. Selected models of spatial regression. 8. Spatial panel models. 9. Basic concepts of geostatistics - semivariance, semivariogram. 10. Geostatistical methods of data interpolation. 11. Introduction to data mining methods. 12. Selected examples of geostatistics applications. Exercises: Projects involving the analysis of spatial data with the use of geostatistical methods, performed in various GIS class software, as well as statistical programs: 1. Study of spatial dependencies with the use of basic statistics of central tendency and dispersion, various global and local measures of spatial autocorrelation and spatial concentration using the Gini index. 2. The use of spatial regression to investigate the relationship between selected phenomena. 3. The use of geostatistical interpolation methods to create probability maps of the occurrence of a selected phenomenon
	GIS Technologies	Lectures: 1. Basic terminology related to Special Information Systems: ordering of concepts. Evolution of the definition and conceptual scope of SIS. 2. How to understand in the context of SIS: technologies, information technologies and IT technologies. Technology and technique. 3. Basic techniques used in SIS (e.g. data visualization, spatial analysis, saving spatial data in a database, spatial data transformation, automation). 4. Introduction to multi-criteria analyses - methodology, selected approaches and tools. 5. SIS techniques supporting the activities of geodetic and cartographic companies.6. Examples of projects implemented in Poland including public tenders. Project: Implementation of a project based on a local revitalization program of a selected urban municipality (development of small road infrastructure). Obtaining spatial information made available on the municipality's website and adapting it to a pre-created database with selected Topographic database BDOT data, with the appropriate attributes necessary to create simple network analyses, based on both data sources. Simple multi-criteria spatial analyses in a mixed approach (boolean and fuzzy functions) to chart a path between two points. The use of tools to visualize path profiles in 2D and 3D.

	Facultative class 1 - Review of contemporary surveying techniques	The principles of operation of selected measurement systems and the conditions for the use of individual measurement techniques in measurement implementation procedures and methods of determining displacements will be presented. A report will be made on the measurements made by videotachimeter. During the project implementation, the student will use the GNSS signal generator 1. statistical analysis of the measured time series 2. filtering with the use of a moving average and a median filter in a given filtering window 3. Fourier analysis of recorded time series 4. making appropriate charts 5. execution of the report
	Facultative class 1 - Advanced use of Matlab in geodetic and cartographic calculations	The principles of operation of selected measurement systems and the conditions for the use of individual measurement techniques in measurement implementation procedures and methods of determining displacements will be presented. A report will be made on the measurements made by videotachimeter. During the project implementation, the student will use the GNSS signal generator 1. statistical analysis of the measured time series 2. filtering with the use of a moving average and a median filter in a given filtering window 3. Fourier analysis of recorded time series 4. making appropriate charts 5. execution of the report
	Facultative class 2 - Spatial data mining	Introduction to Spatial Data Mining. Data preprocessing and spatial data enrichment. Non-classical logics, including fuzzy logic. Rough sets and reducts. Decision trees. Association rules. Spatial concentration analyses. Spatio-temporal trends. Text mining and Twitter spatial data analysis. Big Data. Distributed databases. Distributed data processing
	Facultative class 3 - BIM in investment management	Lectures: BIM Standards and Initiatives; BIM Guides and Execution Planning; Uses of BIM; Levels of BIM; Impact of BIM; The Evolution to Object-Based Parametric Modeling; Parametric Modeling of Buildings; Creating a model based on a point cloud; BIM Environments, Platforms, and Tools Overview of the Major BIM Design Platforms; BIM for Owners and Facility Managers; BEP, Scope of Design Services; BIM Use in Design Processes; BIM for Contractors; Processes to Develop a Contractor Building Information Model; Construction Analysis and Planning; Integration with Cost and Schedule Control and Other Management Functions.
	Facultative class 4 - Machine Learning	1. Introduction to the class. Basic information on unmanned aerial vehicles 2. Legal provisions regarding the use of UAV aviation law 3. Review of photogrammetric UAV platforms and RGB, NIR, multispectral, hyperspectral, LIDAR sensors 4. Planning and development of photogrammetirc missions with the use of UAV 5. Processing of photogrammetric data obtained from the UAV 6. Regulations in the field of geodesy and cartography regarding the use of data from UAV platforms 7. Presentations of exemplary geodetic works using UAV data
	Facultative class 4 - UAV Technologies	Lectures: 1. Introduction to Machine Learning, basic concepts 2. Supervised and unsupervised learning 3. Classification 4. Regression 5. Cluster analysis: hierarchical, k-means, c-means, Kohonen networks 6. Supervised methods: kNN, least distance, maximum likelihood, decision trees, random forests, SVM, Bayes classifier 7. Artificial neural networks: neuron model, multilayer perceptron 8. Training of multilayer perceptron, mathematical model of a neuron 9. Deep neural networks, convolutional neural networks 10. Practical aspects of Machine Learning application in remote sensing 11. Typical problems in Machine Learning: small amount of data, unreliable data, unrepresentative data, overfitting, etc. 12. Methods of increasing model accuracy: extending a set of image features, knowledge transfer from related problems, combined methods 13. Machine learning in time series applications: trend curve fitting, outlier detection, prediction by analytical methods and deep networks (LSTM) 14. Competitive learning and other new trends in Machine Learning, examples of Machine Learning applications in remote sensing and related fields
Specialization courses		
	Field exercises in cartography	1. Introduction to the project. 2. Field works for inventory of tourist trails. 3. Processing field data to store them in a spatial database. 4. Verification of database's spatial data. Spatial data analysis. 5. Developing a simple web application for cartographic visualisation of project data.

	Digital Systems of Map Production	Lectures: Map concept and cartographic technologies, map development process, legal conditions for the production of topographic maps in Poland, structure and applications of the Database of Topographic Objects BDOT10k, symbolisation in production systems, generalisation of spatial data and editorial generalisation, cartographic graticules, marginalia; image recording technologies, graphic image processing techniques, technologies for reproducing tones and colours on a map, DTP technologies: typography, fonts, fonts, text and graphics breaking; technology of the production of topographic and thematic maps. PROJECT CLASSES The project aims to develop a cartographic publication based on the topographic database (reference content) and additional spatial data, constituting the thematic content of the publication. The publication should consist of several or a dozen sheets presenting on a large scale (1: 5'000 or 1: 10'000) an existing or planned linear investment, e.g. a bicycle path, tourist trail, canoe trail, etc.
	Generalisation of Geographic Information **/E**	Cartographic modeling - theoretical aspects. Introduction to the generalization of geographic information. Generalization models: Ratajski, Weibel and Brassel, Shea and McMaster. Objective and subjective, interactive and batch generalization, generalization of the DLMi DCM model. Generalization methods, operators and algorithms. Multi-resolution databases - MRDB Generalization of land relief Tools of generalization of geographic information Application of computational intelligence methods in the process of generalization of spatial information - ANN and FIS. Generalization of raster data - linear and nonlinear filtering. Methodology of geographic information generalization, inference on the basis of obtained results. Application of ANN and FIS systems for nonlinear generalization of raster data (numerical terrain model). Generalization of vector data - selection of operators, algorithms and parameters. Simplification and smoothing of linear and surface data, change of geometric representation, translation, rotation, orthogonalization. Methodology of geographic information generalization, inference on the basis of obtained results. Application of various GIS tools for vector data generalization: ArcGIS, GeoMedia, MapInfo; comparison of the obtained results. Generalization of the relief, iterative removal of TIN model points.
	Computer Graphics in Cartography	Lectures: 1. Functioning of the sense of sight and principles of vision. 2. Visual perception, theories of perception and Gestalt principles. 3. Color, physical and perceptual aspects. 4. Color models, calibration and color profiles. 5. Raster graphics. 6. Handwriting and Typography basics. 7. Vector transformations. 8. Principles of object modelling. 9. Lighting modelling methods. 10. Scanning, vectorization and image processing. 11. Basics of photographic processing. 12. Color separations, PostScript and preparation for printing.
	Mathematical Cartography	Local-directional, local and integral measures of map projection distortion. Methods of presenting mapping distortions. Ways to minimize distortions in cartographic projections. Criteria for minimizing the mapping distortions. Examples of cartographic projections meeting the selected criteria of minimization od distortion. Applications of cartographic projections. Cartographic mappings of a triaxial ellipsoid. Cartographic mapping of irregular objects.

	Thematic Cartography /E	Lectures: Thematic maps and general geographic maps. Graphic variables, their properties and the rules of their application in map editing, combining variables in the design of cartographic signs system. Measurement scales in cartography, their properties and applications. Classifications of cartographic presentation methods. Principles of parametrization of the choropleth, diagram and isoline methods in the GIS environment. Modifications of presentation methods. Official thematic maps: sozological, hydrographic, hydrological, geological. PROJECT CLASSES The aim of the project is to develop a set of thematic maps in the form of a thematic mini-atlas based on the collected spatial and statistical data. The atlas should contain at least one overview map and a set of synthetic thematic maps. The fundamental assumption of the concept of the atlas should be a clearly defined problem or phenomenon to be presented in a cartographic form, e.g. the development of bicycle tourism in Poland compared to other European countries, the issue of population migration in Europe, causes and global effects of climate warming, etc.
	Cartographic 3D Models	Lectures: 1. 3D in cartography: application examples, overview of source data types, data models, applications, meaning of "map" and cartographic according to technological development. 2. What is a 3D model: purpose of modeling vs. form of model and modeling method, types of model structure (raster, vector), model schema standards (CityGML, IFC, etc.), storage formats (3ds, obj, etc.), model creation tools (hardware, software). 3. 3D model creation: ways to represent the shape of reality, ways of assigning additional features (textures, descriptive attributes). 4. Visualization of 3D models: techniques for visualizing 3D models, rendering. 5. Use of 3D models in urban planning analysis: 3D city models, examples from Poland and the worldaround, 3D data standards used for city models (CityGML, IFC), methodology of building 3D city model, software for creating 3D city models and for spatial urban analyses: ESRI City Engine. Project: 1. Developing of cartographic composition using 3D features with ESRI ArcGIS Pro: using spatial data and related statistical data, a phenomenon concerning a specific area (e.g. a city) is presented, visualization uses perspective view, presented data are vector (TIN, MESH) or raster (voxels). 2. Developing a building model in 3D with Trimble Sketchup: shape is modeled, textures are given, model becomes a part of a 3D scene with prepared set of virtual lights, model is rendered in "day" and "night" scenery. 3. Developing a (part of) city model with ESRI CityEngine: the model is built of data taken from project 2, 3D buildings from GUGiK (Polish Head Office of Geodesy and Cartography resources and models taken with parametric modeling technique using BDOT10k buildings data as a source. The developed scene is implemented in a web application.
	Spatial Databases Design /E	Lectures: Repetition and consolidation fundamental knowledge of relational databases. Introduction to analytical methods of information systems design. Conceptual modeling. UML language and selected ISO standards in spatial data modeling. Cartographic presentation model. Principles of creating professional project documentation of geoinformation system. Features and functions of software supporting design processes (CASE software). Analysis of selected models of spatial databases, especially those available within the Polish national Spatial Information Infrastructure (IIP). 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. Methods of harmonizing spatial databases within the framework of the Polish national Spatial Information Infrastructure (IIP).Project:Designing an information system using a spatial database. Performing requirements analysis. Developing use case and business process models. Designing a database conceptual, logical and physical models. Using selected CASE tool. Creating a database prototype within selectde RDB system (Oracle or PostreSQL). The project should use fragments of data models from the national IIP. Creation of as-built documentation.

	Mobile Cartography	Lectures: Basic concepts of mobile systems, mobile cartography and mobile GIS. Location and navigation systems: land, air, sea. Scope of spatial information necessary in location and navigation systems. Overview of mobile device screen parameters (PDA, PNA, tablet, smartphone, standard cell phones, etc.). Specifics of cartographic presentations in mobile systems. Methodology of cartographic presentation in mobile systems. Structures of databases supporting visualization in mobile systems. Characteristics of cartographic tools for creating cartographic presentations in mobile systems Project: Testing of cartographic tools for creating cartographic presentations in mobile systems. Analysis and evaluation of selected location and navigation systems for cartographic accuracy. Design and development of a cartographic presentation for a mobile navigation system.
	Diploma Seminar	Principles of writing an Msc 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
	Selected Topics of Geostatistics	Lectures: 1. Overview of the most important issues related to geoinformatics. 2. Methods of spatial data processing automating in leading GI solutions (commercial and Open Source). Review of the most important languages, frameworks, programming libraries. 3. Fundamentals of Python language. 4. Architecture of a modern geoinformation systems. Multilayer architecture, virtualization, cloud solutions. 5. "Business Logic" layer software (commercial and open source) for creating map services 6. Review of languages and frameworks used to deploy spatial data web applications. 7. Fundamentals of the trio: HTML + CSS + JavaScript. 8. Sample web application implementation built with common programming libraries (Google Maps JS API, OpenLayers) Project: 1. Developing an application to automate spatial data processing using API of selected GIS software and Python language. 2. Developing map services with Geoserver or ArcGIS Server software. 3. Developing a simple web application using the map services developed in project two.
	Advanced Geographic Analyses	Lectures: Directoins of contemporary developement of spatial data models, Data sources for GIS in Poland. Features of conceptual model of spatial database. Modeling of non-spatial joins (1-n and n-m relations) in relational structure and the application in GIS software. Spatial database management systems, optimization of access to data, types of spatial indexes. Spatial analysis: MCA, networks, etc.: algorithms and automation possibilities. Applications of advanced geospatial analysis in environmental management and crisis management. Elements of graph theory its application in GIS, network solutions and algorithms. Projects: 1. Modeling of non-spatial joins (1-n and n-m relations) in relational structure and the application in ArcGIS. 2. Building, editing and verifying of topological realtions in spatial DB. 3. MCA for searching the areas of UAV flights. 4. Construction of geometric networks and analysis in planar graph (for electrical / gas network). 5. Building of Network Data Set in ArcGIS and network analysis in non-planar graph (road network).