Information Package

for Studies in

GEOMATICS ENGINEERING
Universität Stuttgart

European Course Credit Transfer System (ECTS)

Faculty of Aerospace Engineering and Geodesy

Introduction

This information package intends to provide information on all courses offered within "Geomatics Engineering" at University of Stuttgart, Germany.

Most of the courses are offered by the institutes running the programs, namely

- Institute of Geodesy (Geodätisches Institut, GIS),
- Institute of Photogrammetry (Institut für Photogrammetrie, IfP),
- Institute of Navigation (Institut für Navigation, INS), and
- Institute of Engineering Geodesy (Institut für Ingenieurgeodäsie, IIGS)

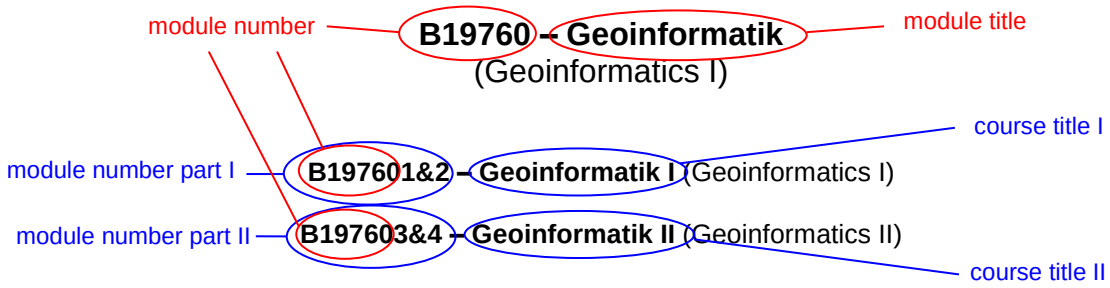
within the faculty of Aerospace Engineering and Geodesy (Fakultät 6: Luft- und Raumfahrttechnik und Geodäsie). Supplementary courses e.g. Mathematics, Computer Science, Law and Humanities etc. are offered by their respective faculties and departments.

The program has unique course contents and examination grading procedures. Every course is scheduled to run weekly. Lectures and labs are not repeated during the semester.

For official examination regulations and other official issues regarding these programs and courses refer to their module handbooks which are available from the C@MPUS - Campus Management Portal of the University of Stuttgart.

Used Abbreviations

A unique module number and a unique module title identify each module. For modules comprising more than one course/module parts, each module part carries its own number consisting of the module number followed by the module part number(s). Each course is characterized by a course description (where available) and a set of keywords explained subsequently.



B19760 – Geoinformatik: Bachelor of Science, module number and title
B197601&2 – Geoinformatik I: Course I/Module part I (number and title)
B197603&4 – Geoinformatik II: Course II/Module part II (number and title)

keywords

Semester:	**4 / SS**	**SWS:**	**3**	**Certificate of credits:**	**m**
Type of course:	**Lecture + Lab**	**Prerequisites:**	**--**	**ECTS-Credits:**	**4**
Language:	**German**	**Details:**		**Institute(s):**	

Semester: recommended Semester
SS = Summer Semester, WS = Winter Semester

SWS: SWS = Hours per week/Semesterwochenstunden

Certificate of credits:
m = oral Examination
s = written Examination

Abbreviations:
n.a = not applicable
n.s = not specified

Variable: Study section:
B = German Bachelor course
M = German Master Course
G = International Master Course "Geoengine"

Institute(s): Responsible Institute(s)

Module numbers are numbers of the C@MPUS - Campus Management Portal of the University of Stuttgart, a data base of all courses offered at University of Stuttgart.

Overview

Geomatics Engineering (GEOENGINE) is the key discipline for measuring, modelling and presentation of geospatial data and processes. Recent technological developments such as global satellite navigation, autonomous navigation, driver assistance systems, digital maps and virtual globes have enhanced Geodesy and Geoinformatics in the public awareness. GEOENGINE meets societal demands for geospatial infrastructures for sustainable development and responsible use of available resources.

Objectives

GEOENGINE has been designed as a compact Master of Science program for international students from academia, government agencies or geomatics engineering companies. It provides advanced education and practical training to those students who wish to widen their perspective and expand their knowledge on numerical techniques for acquiring and modelling geospatial data. Successful completion of the curriculum enables them to create and manage intelligent workflows and services. Based on deep theoretical understanding, sophisticated technology and methods can be flexibly adapted to the necessities of specific applications.

Competences

Geomatics Engineers are professionals for advanced technologies for geospatial data acquisition and management. They are indispensable partners in urban planning, traffic management and sustainable economic development. Therefore, the GEOENGINE Master program provides profound knowledge focused on positioning, navigation and telematics. As future executives in industry and research, graduates of this master program will also be proficient in the following:

- Mastering state-of-the-art technology
- Acquisition, administration and processing of geodata
- Team management
- Research in all fields of Geomatics Engineering

Curriculum

The international program is comprised of solid theoretical foundations in mathematics, theoretical and satellite geodesy and geomethodologies, in addition to applied subjects such as the representation of geodata, positioning, navigation, multisensory integration and geo-telematics. The two-year program consists of three course-based semesters and one semester dedicated to thesis research. The courses are organized in modules. Most of them are mandatory, while two modules are electives. In addition, a two-week practical field work as well as a compact German language pre-course is mandatory. All modules are credited according to the European Credit Point System (ETCS). The language of instruction is English. The program is fully accredited according to the European Standards and Guidelines for Quality Assurance in the European Higher Education Area.

	Semester	1	2	3	4
Compulsory modules	Advanced Mathematics (Module 1)	**6**			
	Geomatics Methodology (Module 2)	**15**			
	- Signal Processing	(5)			
	- Statistical Inference	(5)			
	- Dynamic System Estimation		(5)		
	Engineering Geodesy (Module 3)	**9**			
	- Monitoring	(3)			
	- Kinematic Measurement Systems		(6)		
	Geodesy (Module 4)	**9**			
	- Map Projections & Geodetic Coordinate Systems	(5)			
	- Physical Geodesy		(4)		
	Remote Data Acquisition (Module 5)		**9**		
	- Remote Sensing		(4,5)		
	- Airborne Data Acquisition		(4,5)		
	Representation of Geodata (Module 6)			**9**	
	- Geoinformatics			(6)	
	- Thematic Cartography			(3)	
	Integrated Project (Module 7)		**6**		
	Information and Contract Law (Module 12)			**3**	
	German as a Foreign Language (Module 13)	**6**			
Elective modules	Multisensor Integration in Geodesy and Transport (Module 8)			**9**	
	- Terrestrial Multisensor Systems			(4,5)	
	- Transport Telematics			(4,5)	
	Satellite Geodesy (Module 9)			**9**	
	- Foundations of Satellite Geodesy			(4,5)	
	- Satellite Geodesy Observation Techniques			(4,5)	
	Navigation (Module 10)			**9**	
	- Satellite Navigation			(4,5)	
	- Integrated Positioning and Navigation			(4,5)	
	Computer Vision and Pattern Recognition (Module 11)			**9**	
	- Computer Vision			(4,5)	
	- Pattern Recognition			(4,5)	
M.Sc.-Thesis	Master thesis				**30**
	CP/Sem	**30**	**30**	**30**	**30**

G41210 – Advanced Mathematics (Module 1)

The module aims at establishing a common level of math skills for all students, smoothing out their individual entry levels. It will provide secure skills in calculus, potential theory, and theory of differential equations and Fourier analysis for later use in the other modules of the GEOENGINE curriculum.

G412101&2 – Advanced Mathematics (Höhere Mathematik)	
Ordinary differential equations, Curvilinear systems of coordinates, Line- and surface integrals, Integral theorems of Gauß, Green and Stokes Elliptic differential equations Potential theory	Gewöhnliche Differentialgleichungen, Krummlinige Koordinatensysteme, Kurven- und Oberflächenintegrale, Integralsätze von Gauß, Green und Stokes Elliptische Differentialgleichungen, Potentialtheorie

Semester:	1 / WS	**SWS:**	5	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits:**	6
Language:	English	**Details:**		**Institute(s):**	GIS

G41220 – Geomatics Methodology (Module 2)

This module conveys advanced skills in statistical analysis and optimal processing of geodetic observations. From the different module sections, the student will gain deeper knowledge and experience in the mathematical concepts of static and dynamic modeling approaches. This enables the student to solve for a wide range of problems in the field of network adjustments, Kalman filtering and digital image processing.

G412201&2 – Statistical Inference (Ausgleichungsrechnung und Statistik)	
Basics on linear algebra, parameter adjustment, condition adjustment and mixed model adjustment, random variables, probability density functions, error propagation, hypothesis testing, internal and external reliability	Grundzüge der linearen Algebra, Ausgleichung nach vermittelnden und bedingten Beobachtungen, gemischtes Modell, Zufallsvariable, Wahrscheinlichkeitsdichten, Fehlerfortpflanzung, Hypothesentests, innere und äußere Zuverlässigkeit

Semester:	1 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits**	5
Language:	English	**Details:**		**Institute(s):**	GIS

G412203&4 – Dynamic System Estimation (Schätzverfahren in dynamischen Systemen)	
Review of parameter estimation within the Gauß-Markov-Model, sequential parameter estimation, linear Ordinary Differential Equation Systems, linear/linearized dynamic models, Stochastic Processes, Power Spectral Density, filters, smoothing procedures, Kalman Filter	Rückblick auf Parameterschätzung im Gauß-Markov-Modell, sequentielle Parameterschätzung, lineare gewöhnliche Differentialgleichungssysteme, lineare/linearisierte dynamische Modelle, Stochastische Prozesse, Spektrale Leistungsdichte, Filter, Glättungsverfahren, Kalmanfilter

Semester:	2 / SS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits:**	5
Language:	English	**Details:**		**Institute(s):**	INS

G412205&6 – Signal Processing (Signalverarbeitung)	
Characterization of digital signals in space and frequency domain, sampling, interpolation of discrete signals, digital filters, recursive filters, signal smoothing, Kalman filtering, introduction to the MATLAB signal processing toolbox	Beschreibung digitaler Signale im Orts- und Frequenzbereich, Abtastung, Interpolation diskreter Signale, Digitale Filter, Rekursive Filter, Signalglättung, Kalman Filter, Einführung in die MATLAB Signal Processing Toolbox

Semester:	1 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits:**	5
Language:	English	**Details:**		**Institute(s):**	IfP

G48400 – Engineering Geodesy (Module 3)

This module provides the student with profound knowledge of classical and modern geodetic concepts. Through the individual module sections, the student will appreciate the fundamental role of coordinate systems and coordinate frames in Geomatics engineering.

G484001&2 – Monitoring (Monitoring)	
Monitoring networks and point determination, Inclination measurements, Hydrostatical leveling, Alignment, plumbing methods, additional sensors, Deformation analysis using the congruency model: two-and multi-epoch comparison, global test, sensitivity test for localization of deformations	Überwachungsnetzwerke und Punktbestimmung, Neigungsmessung, hydrostatisches Nivellement, Alignement, Lotungsverfahren, zusätzliche Sensoren, Deformationsanalyse im Kongruenzmodell: Zwei- und Mehr-Epochenvergleich, Globaltest, Hypothesentest zur Lokalisierung von Deformationen

Semester:	1 / WS	**SWS:**	2	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits:**	3
Language:	English	**Details:**		**Institute(s):**	IIGS

G484003&4 – Kinematic Measurement Systems (Kinematische Messsysteme)	
Graphical programming: introduction and data acquisition, Recapitulation of tachymeter techniques and measurements, Robot total stations, GNSS, other kinematic sensors, Positioning for moving objects , Vehicle models, Prediction and filtering, e.g. Kalman filter, Basics of control theory, Integration of kinematic measurements into control circles, Construction machine guidance, Project at construction machine simulator	Grafisches Programmieren: Einführung und Datenerfassung, Wiederholung von Tachymetertechniken und Tachymetermessmethoden, Robot-Tachymeter, GNSS, weitere kinematische Sensoren, Positionsbestimmung bewegter Objekte, Prädiktion und Filterung, z. B. Kalman Filter, Grundlagen der Regelungstechnik, Integration kinematischer Messmethoden in Regelkreise, Baumaschinensteuerung, Projekt mit dem Baumaschinensimulator

Semester:	2 / SS	**SWS:**	4	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**		**ECTS-Credits:**	6
Language:	English	**Details:**		**Institute(s):**	IIGS

G41230 – Geodesy (Module 4)

This module provides the student with profound knowledge of classical and modern geodetic concepts. Through the individual module sections, the student will appreciate the fundamental role of coordinate systems and coordinate frames in geomatics engineering.

G412301&2 – Map Projections & Geodetic Reference Systems (Kartenprojektionen & Geodätische Koordinatensysteme)	
Basics on differential geometry of surfaces, geometry of sphere and ellipsoid-of-revolution, spherical map projections, optimal map projections, legal map projections (Gauß-Krüger/UTM), deformations and deformation measures, 2D and 3D coordinate systems and datum transformation models	Grundzüge der Differentialgeometrie von Flächen, Geometrie von Kugel und Rotationsellipsoid, sphärische Kartenprojektionen, optimale Kartenprojektionen, legale Kartenprojektionen (Gauß-Krüger/UTM), Deformationen und Deformationsmaße, 2D und 3D-Koordinatensysteme und Datumtransformationen

Semester:	1 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210	**ECTS-Credits:**	5
Language:	English	**Details:**		**Institute(s):**	GIS

G412303&4 – Physical Geodesy (Physikalische Geodäsie)	
Elements of potential theory, gravitation and gravity, measurement principles of gravimetry, gravity networks, approaches to solving the Laplace equation, geoid determination, height systems	Elemente der Potenzialtheorie, Gravitation und Schwere, Messprinzipien der Gravimetrie, Schwerenetze, Ansätze zur Lösung der Laplace-Gleichung, Geoidberechnung, Höhensysteme

Semester:	2 / SS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210	**ECTS-Credits:**	4
Language:	English	**Details:**		**Institute(s):**	GIS

G41240 – Remote Data Acquisition (Module 5)

The objective of this module is to provide the student with a thorough understanding of methods and modern instrumentation for the acquisition of spatial data using airborne and space-borne platforms.

G412401&2 – Remote Sensing (Fernerkundung)	
Definition and tasks of remote sensing, structure of remote sensing systems, history of earth remote sensing, satellite orbits (Kepler orbits, orbit parameters, special orbit types, field-of-view of a satellite), overview of modern satellite remote sensing systems, electromagnetic radiation (formation of EM radiation, radiation and energy, radiation models, characteristic quantities of EM waves, polarization, energy and spectral distribution, propagation of EM waves, measurement of EM wave properties, sources of radiation), radiation and material (absorption, emission, Black Body, radiation laws), reflection and transmission (degree of reflection, Backscatter cross-section, degree of transmission, extinction, types of diffraction), capture and measurement of radiation (radiometers, techniques of capture (photo-chemical, photo-electrical, thermo-electrical, electrical)), imaging, collection and decomposition of radiation (optical systems, radiometers, spectral separation by deflection, bending, interference and filters), imaging systems, geometric considerations (profiler, scanner, opto-mechanical procedures, detector geometry), active micro-wave sensor systems (structure, peculiarities, Radar equation, scatterometers, altimeters, side-looking Radar, Synthetic Aperture Radar (SAR), SAR interferometry), storage and representation of remote sensing data (digitization and transmission of data, ground segment), processing of remote sensing data (radiometric and geometric corrections, classification)	Definition und Aufgaben der Fernerkundung, Struktur eines Fernerkundungssystems, Geschichte der Erderkundung, Satellitenbahn (Keplersche Gesetze, Bahnparameter, spezielle Bahntypen, Sichtfeld eines Satelliten), Überblick über moderne Satelliten-Fernerkundungs-systeme, Elektromagnetische Strahlung (Entstehung von elektromagnetischer Strahlung, Strahlung und Energie, Strahlungsmodelle, Kenngrößen elektromagnetischer Wellen, Polarisation von Transversalwellen, Energiegehalt und spektrale Verteilung, Entstehungsmöglichkeiten, Ausbreitung und Messgrößen von Strahlung, Strahlungsquellen), Strahlung und Körper (Absorption, Emission, Schwarzkörper, Strahlungsgesetze), Reflexion und Transmission (Reflexionsgrad, Rückstreuquerschnitt, Transmissionsgrad, Extinktion, Arten der Streuung), Erfassung und Messung von Strahlung (Radiometer, Detektionsverfahren (fotochemisch, fotoelektrisch, thermoelektrisch, elektrisch)), Abbildung, Strahlungssammlung und -zerlegung (Sammlung durch optische Systeme, Radiometer; spektrale Zerlegung durch Brechung, Beugung und Interferenz und Filter), Abbildungssysteme und Aufnahmegeometrien (Profiler, Scanner, optomechanische Ablenkverfahren, Detektoranordnungen, Parameter der Aufnahmesysteme), Aktive Mikrowellen-Sensorsysteme (Aufbau und Besonderheiten, Radargleichung, Scatterometer, Altimeter, Seitensichtradar, synthetische Apertur, SAR-Interferometrie), Speicherung und Darstellung von Daten (Digitalisierung, Datenübertragung, Bodensegment), Verarbeitung von Fernerkundungsdaten (radiometrische und geometrische Korrektur, Klassifikation)

Semester:	2 / SS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IfP

G412403&4 – Airborne Data Acquisition (Photogrammetrie)	
Airborne Sensor Systems (images, LIDAR, RADAR), elementary math relations, spatial resection, forward intersection (3D), bundle block adjustment, integration of GPS/DGPS and INS/IMU observations, Digital Mapping Cameras and calibration, digital image matching (for DTM generation), LIDAR systems, LIDAR surface models, advanced LIDAR applications, RADAR imaging and HSAR	Luftgestützte Sensorsysteme (Kameras, LIDAR, RADAR), elementare mathematische Beziehungen, Rückwärtsschnitt, Vorwärtsschnitt (3D), Bündelblockausgleichung, Integration von GPS/DGPF und INS/IMU Beobachtungen, digitale photogrammetrische Kameras, digitale Bildverarbeitung (zur DGM Generierung), LIDAR Systeme, LIDAR Oberflächenmodelle, erweiterte LIDAR Anwendungen, RADAR Datenerfassung und HSAR

Semester:	2 / SS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IfP

G41250 – Representation of Geodata (Module 6)

Within this module, the students will understand the methods and technologies of spatial data handling, analysis and presentation. The students will be enabled to acquire the relevant Geodata for a complex application and to perform the appropriate geometric, topologic and thematic modeling, analysis and presentation.

G412501&2 – Geoinformatics (Geoinformatik)	
Introduction to GIS, data capture (methods, data sources, hardware, data types and data structures), data administration (file systems, databases, data models), representation schemes, operations in databases, spatial access and data structures, official information systems	Einführung in GIS, Dateneingabe (Methoden, Quellen, Hardware, Interaktion, Datentypen, Datenstrukturen, Bedeutung der einzelnen Datenquellen), Datenverwaltung (Dateiensysteme, Datenbanksysteme, Datenmodelle), Repräsentationsschemata, Operationen (Eingabe, Löschen, Verändern), raumbezogene Zugriffs- und Speicherstrukturen, Amtliche Informationssysteme

Semester:	3 / WS	**SWS:**	4	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210	**ECTS-Credits:**	6
Language:	English	**Details:**		**Institute(s):**	IfP

G412503&4 – Thematic Cartography (Thematische Kartographie)	
Basics of cartography, analysis for information systems requirements (focus on thematic maps), scientific cartography, cognitive maps, structure of the geo-data market, cost structures for the generation of maps, techniques for homogenizing data sets (matching and merging), map design, animated maps, thematic maps for individual and public transport	Kartographische Grundlagen, Anforderungsanalyse für Informationssysteme (Schwerpunkt: Thematische Kartendarstellungen), wissenschaftliche Kartografie, kognitive Karten, Struktur des Geodatenmarktes, Kostenstrukturen zum Erstellen thematischer Karten, Homogenisierungstechniken unterschiedlicher Datenquellen (Matching und Merging), Kartengestaltung, animierte Kartendarstellungen, thematische Karten im Verkehr

Semester:	3 / WS	**SWS:**	2	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210	**ECTS-Credits:**	3
Language:	English	**Details:**		**Institute(s):**	IIGS

G41280 – Integrated Project (Module 7)

This module is the synthesis of all knowledge acquired in previous modules. It enables students to analyze real-life Geomatics Engineering tasks and to solve those tasks and problems with an engineering approaching an autonomous way.

G412801 – Integrated Project (Integriertes Feldprojekt)	
Varying topics will be dealt with; examples of the past project are "geoid determination", "development of a tourist information system" and "setting out of a tunnel". The students work in a team for ten days to realize a project on a special topic. The individual measurement, evaluation and analysis tasks will be carried through in small working groups. The lecturers supervise the work and guide the students to solve occurring problems. Before the fieldwork the students have to prepare their part of the common project. This task comprises the presentation of a work package as well as a task description for the colleagues. After the fieldwork the students have to prepare a final report and to present the results of their work package	Wechselnde Themenschwerpunkte werden in Projektform behandelt. Beispiele für Projekte sind "Geoidbestimmung", "Aufbau eines touristischen Informationssystems" oder "Absteckung eines Tunnels". Die Studierenden arbeiten für 10 Tage an der Umsetzung eines Projektes, welches in unterschiedliche Arbeitspakete gegliedert ist. Die Planung, Messung, Auswertung und Analyse wird in kleinen Arbeitsgruppen umgesetzt. Die Lehrenden stehen in leitender und beratender Funktion zur Verfügung. Vor der Feldarbeit hat jeder einzelne der Studierenden jeweils ein Arbeitspaket des Gesamtprojekts vorzubereiten. Diese Vorbereitung umfasst auch eine Präsentation des Arbeitspaketes vor der Projektgruppe bestehend aus Studierenden und Lehrenden. Nach der Feldarbeit ist ein gemeinsamer Abschlussbericht zu erstellen und die Ergebnisse der Arbeitspakete sind gleichfalls von den einzelnen Studierenden im Rahmen eines Vortrags vor der Projektgruppe zu präsentieren

Semester:	2 / SS	**SWS:**	10 days	**Certificate of credits:**	m
Type of course:	Lab + practical course + presentation	**Prerequisites:**	G41210 G41220 G41230 G41240	**ECTS-Credits:**	6
Language:	English	**Details:**		**Institute(s):**	GIS, IfP, IIGS, INS

G43320 – Information and Contract Law (Module 12)

The module imparts basic features of the contract, media and internet law. The student learns to recognize the separate functions and business processes, their main subjects and their duties and responsibilities. This results in a better understanding of the role and use of information technology in businesses across all functions.

G43320 – Information and Contract Law (Informations- und Vertragsrecht)	
Objectives and mechanism of law, the legal system (overview), the system of national law, the European system of law, international law Contracts: General remarks, requirements for a contract in general, terms of contract, irregularities in the performance of the contract, types of contract, disputes, arbitration, lawsuits The law on torts (liability): general remarks tort liability based on fault, product liability Selected field of law (overview): Labour law, the law of business associations, competition law, copyright, patent, brands and related rights, data protection, other areas of interest (i.e. new European legislation on e-commerce)	Nicht verfügbar

Semester:	3 / WS	**SWS:**	2	**Certificate of credits:**	s
Type of course:	Lecture	**Prerequisites:**	--	**ECTS-Credits:**	3
Language:	English	**Details:**		**Institute(s):**	n.s

G41260 – German as Foreign Language (Module 13)

The module conveys a basic knowledge about German grammar, vocabulary, regional and cultural studies and it provides basic conversations skills. At the end of the module, the students will have acquired the following skills: Listening comprehension, Reading comprehension, Grammar, Text production.

G412601&2 – German as Foreign Language (Deutsch als Fremdsprache)	
Grammar and vocabulary; Exercises in listening comprehension; Development of strategies for reading of complex texts; Development of competences in daily-life communication; Intercultural problems; Living and working in Germany; Leisure and travelling; Mass media	Nicht verfügbar

Semester:	1 / WS	**SWS:**	**4-**6 weeks compact course	**Certificate of credits:**	s + m
Type of course:	Lecture + lab	**Prerequisites:**	--	**ECTS-Credits:**	6
Language:	German	**Details:**		**Institute(s):**	n.s

G77800 – Multisensor Integration in Geodesy and Transport (Module 8)

Elective module (consisting of the courses Terrestrial Multisensor Systems and Transport Telematics)

G778001&2 – Terrestrial Multisensor Systems (Terrestrische Multisensorsysteme)	
Definition of terrestrial multi-sensor systems, analogue and digital data registration, bus-based systems, analogue-digital conversion, special kinematic sensors, dead reckoning, coordinate systems, sensor corrections and reductions, synchronization, real time data processing, evaluation using Kalman filter, project: development of a multi-sensor system	• Definition Terrestrische Multisensorsysteme; analoge und digitale Messdatenerfassung, • Synchronisation der Messdatenerfassung • Echtzeit: Definition, Realisierung in Hard- und Software • Datenverarbeitung: Koordinatensysteme, Reduktionen und Korrektionen • Graphische Programmierung: Messwerterfassung und Bearbeitung • Spezielle kinematische Sensoren, z.B. Odometer und Korrelationsgeschwindigkeitsmesser • Integration Terrestrischer Sensoren • Projekt Multisensorsysteme in Teamarbeit

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IIGS

G778003&4 – Transport Telematics (Verkehrstelematik)	
Digital road network, communication technologies, positioning and navigation systems, traffic management systems, computer assisted operation-al control systems, information services for traffic, driver assistance systems	Digitale Straßenkarte, Kommunikationstechnologien, Positionierung, Navigationssysteme, Verkehrsmanagementsysteme, Fahrerassistenzsysteme

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220 G41240	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IIGS

G48420 – Satellite Geodesy (Module 9)

Elective module (consisting of the courses Foundations of Satellite Geodesy and Satellite Geodesy Observation Techniques)

G484201&2 – Foundations of Satellite Geodesy (Grundlagen der Satellitengeodäsie)

Part 1: Time systems: Atomic time (TAI), Julian Date, Coordinated Universal Time (UTC, UT1), Apparent and mean sidereal time of Greenwich. Earth: rotation: Precession, nutation, polar motion **Part 2:** Reference systems and reference frames: celestial reference system (ICRS), Earth-fixed reference systems (ITRS, WGS84, Rauenberg system) **Part 3:** Signal propagation: Wave equation, refraction, ionospheric corrections, tropospheric corrections **Part 4:** Orbital motion: Two-body problem, Keplerian elements, orbital disturbances	**Teil 1:** Zeitsysteme: Atomzeit (TAI), Julianisches Datum, Koordinierte Universalzeit (UTC,UT1), Scheinbare und mittlere Sternzeit von Greenwich. Erdrotation: Präzession, Nutation, Polbewegung **Teil 2:** Referenzsysteme und Referenzrahmen: Zälestisches Referenzsystem (ICRS), Erdfeste Referenzsysteme (ITRS, WGS84, Rauenberg System) **Teil 3:** Signalausbreitung: Wellengleichung , Refraktion, Ionosphärische Korrekturen, Troposphärische Korrekturen **Teil 4:** Bahnbewegung: Zweikörperproblem. Keplersche Bahnelemente, Bahnstörungen

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	GIS

G484203&4 – Satellite Geodesy Observation Techniques (Beobachtungstechniken der Satellitengeodäsie)

Satellite Laser Ranging, normal points, satellite altimetry, sea surface topography, crossover analysis, very long baseline interferometry, correlation, Global Positioning System, ground segment, space segment, user segment, Pseudo Random Code, P-Code, C/A-Code, ephemeris data, Code Delay Loop, Costas Loop, pseudorange from code- and phase observations, linear combination, navigation solution, dilution of precision, single difference solution, double difference solution, cycle-slip detection ambiguities, error budget, ionospheric und tropospheric delays, multipath	Satellite Laser Ranging, Normalpunktbestimmung, Satellitenaltimetrie, Meerestopographie, Kreuzungspunktausgleichung, Interferometrie langer Basen, Korrelationsanalyse, Global Positioning System, Kontrollsegment, Raumsegment, Nutzersegment, Pseudo Random Code, P-Code, C/A-Code, Ephemeridendaten, Code Delay Loop, Costas Loop, Pseudodistanzen aus Code- und Phasenbeobachtungen, Linearkombinationen, Navigationslösungen, Dilution of Precision, Single Difference-Lösung, Double-Difference-Lösung, Cycle-Slip-Bestimmung, Mehrdeutigkeiten, Fehlerbudget, Ionosphärische und troposphärische Verzögerungen, Multipath

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	GIS

G48430 – Navigation (Module 10)

Elective module (consisting of the courses Satellite Navigation, and Integrated Positioning and Navigation)

G484301&2 – Satellite Navigation (Satellitennavigation)	
Principle of operation of the satellite navigation system GPS: reference systems, time systems, satellite orbits – Kepler orbits and perturbed Kepler orbits, computation of satellite positions, transmission of orbit parameters, precise ephemeris, satellite constellation. Signal structure: carrier signal, codes, message, choice of carrier wavelength, modulation, generation of PRN-codes, code properties, code correlation properties, signal propagation (Maxwell's equations, refractivity, dispersive media, group velocity,…), description of ionospheric and tropospheric refraction, (Appleton-Harttree formula, Smith & Weintraub formula), refraction correction models (TEC values, Klobuchar model, Hopfield model), modeling of other measurement errors (clock errors, orbit errors), receiver tasks, signal identification, time-of-flight measurement, signal separation, receiver design, pseudorange modeling, pseudorange positioning, NMEA format for navigation devices, differential positioning techniques (SAPOS, GBAS, SBAS), correction data (type, transmission, formats: RTCM, RTCA)	Funktionsprinzip des Satellitennavigationssystems GPS: zugehörige Bezugssysteme (WGS84, ITRFxx), Zeitsysteme, Satellitenbahnen - Erweiterung der ungestörten Keplerbewegung auf gestörte Keplerbewegung, Berechnung der Satellitenposition, Darstellung und Übertragung der Orbitparameter, Präzise Ephemeriden, Konstellation. Signalaufbau: Träger, Codes, Message, zur Wahl der Wellenlänge des Trägers, Modulation, Generierung und Eigenschaften von PRN-Codes, Korrelationsverhalten der Codes, Ausbreitung der GPS-Signale (Maxwells Gleichungen, Refraktivität, dispersive Medien, Gruppengeschwindigkeit,…), Beschreibung von ionosphärischer und troposphärischer Refraktion (Appleton-Harttree-Formel, Smith- & Weintraub-Formel), Korrekturmodelle für Refraktion (TEC Values, Klobuchar Modell, Hopfield-Modell), Modellierung weiterer Fehlereinflüsse auf die Messung (Uhrenfehler, Bahnfehler), Aufgaben des Empfängers, Signalidentifizierung, Prinzip der Laufzeitmessung, Unterscheidung von Signalen, Empfängerdesign, Modellbildung für Pseudostrecken, Positionierung mit Auswertung der Codeinformation, NMEA: Standard-Format für die Navigation, Differentielle Techniken (SAPOS, GBAS, SBAS), Analyse von Korrekturdaten (Arten, Übertragung, Formate: RTCM, RTCA)

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	INS

G484303&4 – Integrated Positioning and Navigation (Integrierte Positionierung und Navigation)	
Coordinate systems, coordinate transformations, direction cosine matrices (DCM), parameterization of the DCM, rotational velocity, Gyroscopes (mechanical, optical, MEMS), Accelerometers (mechanical, MEMS), Platform Systems, Strap-Down-Systems, INS Differential Equations (ECEF System, Local Level System), integration procedures, error estimation and monitoring	Koordinatensysteme, Koordinatentransformationen, Richtungskosinus Matrizen (DCM), Parametrisierung der DCM, Rotationsgeschwindigkeiten, Kreisel (mechanisch, optisch, MEMS), Beschleunigungsmesser (mechanisch, MEMS), Plattformsysteme, Strap-Down-Systeme, INS Differentialgleichungen (ECEF System, lokales topozentrisches System), Integrationsverfahren, Fehlerschätzung und -kontrolle

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	s
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	INS

G77790 – Computer Vision and Pattern Recognition (Module 11)

Elective module (consisting of the courses Computer Vision and Pattern Recognition)

G777901&2 – Computer Vision (Computervision)	
Automatic image matching by intensity and feature based methods, automatic image orientation by Structure-from-Motion, image based 3D surface reconstruction using dense multi-view stereo, image segmentation	Automatische Bildzuordnung durch intensitäts- und merkmalsbasierte Verfahren, Bildorientierung durch Structure-from-Motion, bildbasierte 3D Oberflächenrekonstruktion durch dichte Mehrbildzuordnung, Bildsegmentierung

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	m
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220 G41240	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IfP

G777903&4 – Pattern Recognition (Mustererkennung)	
Feature space, different types of features, curse of dimensionality, Model based and statistical methods, supervised and unsupervised classification, Classification methods: Minimum distance, maximum likelihood, Bayes, decision tree, random forest, support vector machine, neural networks, and random fields, confusion matrix, overall accuracy, producer's and user's accuracy	Merkmalsraum und unterschiedliche Merkmale, Fluch der Dimensionalität, modellbasierte und statistische Methoden, überwachte und unüberwachte Klassifikation, Verfahren der Klassifikation: Minimum Distanz, Maximum Likelihood, Bayes'sche Entscheidungsbäume, Random Forest, Support Vektor Machine, Neuronale Netzwerke und Random Fields, Konfusionsmatrix, Overall Accuracy, Producer's und User's Accuracy

Semester:	3 / WS	**SWS:**	3	**Certificate of credits:**	m
Type of course:	Lecture + lab	**Prerequisites:**	G41210 G41220 G41240	**ECTS-Credits:**	4,5
Language:	English	**Details:**		**Institute(s):**	IfP

G80920 – Master Thesis

The candidates are to demonstrate their ability to complete and document a well-defined research project within a given time frame.

G80920 – Master Thesis (Masterarbeit)	
To be done according to the thesis topic	Dem Thema der Masterarbeit entsprechend

Semester:	4 / SS	**SWS:**	6 months	**Certificate of credits:**	m
Type of course:	n.a	**Prerequisites:**	at least 60 CP	**ECTS-Credits:**	30
Language:	English	**Details:**		**Institute(s):**	GIS, IfP, IIGS, INS