Fundamentals of Space Technology

Module title:	Credits:	Responsible person:
Fundamentals of Space Technology	9	Yoon, Zizung
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	zizung.yoon@tu-berlin.de

Learning Outcomes

The module imparts the fundamentals of space technology. Space systems engineers need general knowledge in several technical and programmatic subjects in space engineering. This knowledge allows them to classify their space projects with respect to the application area, space history, space environment, possible orbits, launch vehicle options, and many other aspects. The module also introduces software tools that are relevant to space engineers. The students will be able to use these tools and apply the skills in other modules and in their careers.

After successful completion of this course, students will be able to:
- identify and describe the critical elements of a space mission,
- name the key historic events and figures in space history,
- critically discuss equality in the history and future of spaceflight,
- list and describe different areas of utilization of space,
- explain the challenges of the space environment for a space mission and propose solutions to overcome them,
- use scientific tools to perform numerical simulations and design space systems,
- use software tools to manage and document scientific work in a professional environment,
- explain the role and tasks of a space systems engineer,
- assess the complexity of a satellite mission,
- explain the characteristics of orbits, reference frames, and flight mechanics laws,
- calculate basic orbit maneuvers,
- explain the basic principles of rocketry and the main elements of a rocket engine,
- calculate basic parameters of a rocket (e.g. masses, thrust force, specific impulse, and velocities),
- explain the basic functional and structural layout of solid and liquid propellant launch vehicles,
- describe the systems and elements of launch vehicles,
- describe the procedures and logistics relevant to building and operating launchers (e.g. integration, tests, launch complex, launch procedures, recovery).

Content

Fundamentals of Space Technology 1 covers:
- History of spaceflight
- The utilization of space
- Engineering tools (e.g. MATLAB, CAD software, Git, GMAT)
- Numerical simulations
- Scientific documentation with LaTeX
- The space environment
- Human spaceflight
- Space systems engineering
- Complexity of satellite systems
- Reference coordinate frames
- Orbital mechanics

Fundamentals of Space Technology 2 covers:
- Rocketry
- Launch vehicles

Module Components

Course Name	Type	Number	Cycle	SWS
Fundamentals of Space Technology 1	VL		SS	4
Fundamentals of Space Technology 2	VL		WS	2

Workload and Credit Points

Fundamentals of Space Technology 1 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	8.0h	120.0h
			180.0h

Fundamentals of Space Technology 2 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Self-study of lecture materials	15.0	4.0h	60.0h
			90.0h

The Workload of the module sums up to 270.0 Hours. Therefore the module contains 9 Credits.

Description of Teaching and Learning Methods

The module consists of a theoretical lecture, exercises and homework.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Throughout both semesters, assignments and quizzes on the theoretical content are given.
Every student gives a short presentation about a selected topic in space engineering and his/her oral feedback on selected topics in space engineering is graded.
The course is concluded with a final test about the whole content of the lecture course.

Test elements	Categorie	Points	Duration/Extent
Assignments and quizzes (FST 2)	flexible	25	30 h
Assignments and quizzes (FST 1)	flexible	45	60 h
Test (FST 1)	written	20	60 min
Test (FST 2)	written	10	60 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
available	available

Recommended literature:

Handbuch der Raumfahrttechnik, Hallmann, W. und Ley, W., München, Wien, Hanser 1999, 792 S

International Reference Guide to Space Launch Systems, Isakowitz, Steven J., American Institute of Aeronautics and Astronautics, Inc., Reston, VA, London, Eurospan 2003. - 550 S

Raumfahrtsysteme : eine Einführung mit Übungen und Lösungen, E. Messerschmidt ; S. Fasoulas. - Berlin u.a.: Springer, 2000. 533 S

Rocket propulsion elements, G. P. Sutton; O. Biblarz, 7. ed.,New York [u.a.] Wiley, 2001, 751 S

Space Stations. Systems and Utilization, E. Messerschmid, R. Bertrand, Springer 1999, 566 S

Assigned Degree Programs

This module is not used in any degree program.

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Satellite Technology

Module title:	**Credits:**	**Responsible person:**
Satellite Technology	6	Avsar, Cem
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	cem.avsar@tu-berlin.de

Learning Outcomes

Satellites are complex systems that consist of payloads and up to seven subsystems that serve to accomplish the mission objectives. This module provides insights about the technologies and design approaches for each satellite subsystem. The knowledge and skills taught in this module are fundamental for space systems engineers.

After successful completion of this module, students will be able to
- describe the specific tasks of each satellite subsystem,
- explain the main design drivers of each satellite subsystem,
- name and identify all commonly used satellite technologies,
- explain the working principles of the most relevant satellite technologies,
- discuss the advantages of different approaches for designing each satellite subsystem,
- calculate technical budgets for satellites (e.g. mass, power, thermal),
- recognize the interdependencies between satellite subsystems.

Content

The module starts with the classification of satellites and their main applications. The module then addresses each of the satellite subsystems one after the other. The main tasks, design drivers, technologies, working principles, budgets, methods and interfaces of each subsystem are discussed. The following subsystems are addressed in this module:
- Structure and Mechanisms (S&M)
- Thermal Control Subsystem (TCS)
- Attitude Control Subsystem (ACS)
- Electrical Power Subsystem (EPS)
- On-Board Data Handling (OBDH)
- Telemetry, Tracking & Command (TT&C)
- Satellite propulsion

Module Components

Course Name	Type	Number	Cycle	SWS
Satellite Technology	VL		SS	4

Workload and Credit Points

Satellite Technology (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Assignments	7.0	10.0h	70.0h
Self-study of lecture materials	15.0	2.0h	30.0h
Exam preparation	1.0	20.0h	20.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module covers all subsystems of satellites in technical detail. Subsystem experts give lectures on specific aspects of satellite technologies and further elaborate on their field of work with examples from real satellite missions. Homework assignments about every subsystem help the student to deepen the knowledge and apply engineering skills and tools to define satellite subsystems.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Schriftliche Prüfung	English	The 3 hour written exam contains questions about each satellite subsystem. An exam question catalogue supports the students during exam preparations.

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Recommended literature:

Berlin, Peter, Satellite Platform Design, Kiruna: Luleå University of Technology Kiruna, 2014.
Charles D. Brown, Elements of Spacecraft Design, Reston, 2002.
Fortescue, P., Stark, J., Swinerd, G., Spacecraft System Engineering, Chichester, 2003.
Griffin, D. Michael, French, R. J., Space Vehicle Design, 2004.
Ley, W., Wittmann, K., Hallmann, W., Handbook of Space Technology., Chichester: John Wiley & Sons, Ltd, 2009.
Macdonald, M., Badescu, V., The International Handbook of Space Technology., Heidelberg: Springer, 2014.
Pisacane, Moore, Fundamentals of Space Systems, 2005.
Wiley, L. J., Wertz, J. R., Space Mission Analysis and Design., El Segundo: Microcosm Press, 2005.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Space Electronics

Module title:	Credits:	Responsible person:
Space Electronics	6	Avsar, Cem
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	cem.avsar@tu-berlin.de

Learning Outcomes

Nowadays, it is required that space systems engineers have basic knowledge and skills in electronics. Electronics and electrical hardware and software are significant parts of any space mission. The systems engineer must understand the main requirements on spacecraft equipment and their interconnections with respect to electrical characteristics and interfaces. The module imparts the practical skills relevant to designing hardware and software for a spacecraft.

After completion of the course, the student will be able to
- recognize the importance of having knowledge in electronics as space systems engineer,
- recognize conventions (e.g. names, symbols, units) that are commonly used in electronics,
- explain the concepts of electrical potential (e.g. voltage, current, work, power, DC, AC),
- recognize the hazards of working with electronics,
- use basic laboratory equipment for electronics (e.g. multimeter, power supply, oscilloscope, frequency generator),
- apply basic laws of electronics for circuit design (e.g. voltage, current, work, power, Ohm’s law, Kirchhoff’s laws),
- use basic analog parts for circuit design (e.g. resistor, capacitor, diodes, transistors, op-amps),
- design basic circuit diagrams for the purpose of interfacing with equipment (e.g. sensors, actuators, computers),
- use breadboards for prototyping electrical circuits,
- simulate the behavior of circuits using software tools,
- design printed circuit boards,
- explain the processes of manufacturing and procuring printed circuit boards,
- solder circuit boards,
- interpret datasheet of integrated circuits,
- connect and use any integrated circuit,
- apply basic laws of digital electronics (binary coding, binary calculations, hexadecimal, gate logic),
- explain the internal composition of microcontrollers,
- use basic functions of a microcontroller (e.g. interrupts, I/Os, timer, ADC, PWM, communication interfaces, memory),
- controls sensors and actuators using a microcontroller (e.g. temperature sensor, IMU, servo),
- explain the challenges of space electronics design,
- explain the approach for the design, realization, and qualification of electronics in the different phases of a space project,
- describe the general electrical architecture of a satellite,
- describe special features of space electronics design (e.g. current limiting, latch-up protection, redundancy),
- select the relevant ECSS standards for electrical design,
- recognize the challenges of spacecraft on-board software design,
- explain the software architecture of a satellite,
- practice the steps of the software development process.

Content

The module consists of two lecture courses. In Space Electronics 1, the focus is set on introducing the student to analog electronics, handling basic hardware and software tools. Space Electronics 2 sets a focus on digital electronics. The following main topics are covered in the course.
- Basic analog parts (e.g. resistor, capacitor, diode, transistor, op-amp)
- Using basic electrical laws (e.g. Ohm's law, Kirchoffs laws)
- Design and simulation of electrical circuits (e.g. KiCAD, LTSpice)
- Handling of laboratory equipment (e.g. mulitmeter, oscilloscope)
- Basics of digital electronics (e.g. ICs, boolean algebra, microcontrollers)
- Programming of microcontrollers
- Hardware related electronic design aspects for spacecraft
- Software related electronics design aspects for spacecraft

Module Components

Course Name	Type	Number	Cycle	SWS
Space Electronics 1	VL		SS	2
Space Electronics 2	VL		WS	2

Workload and Credit Points

Space Electronics 1 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Homework assignments	3.0	10.0h	30.0h
Self-study of lecture materials	15.0	1.0h	15.0h
Test preparation	1.0	15.0h	15.0h
			90.0h

Space Electronics 2 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Test preparation	1.0	15.0h	15.0h
Self-study of lecture materials	15.0	1.0h	15.0h
Project work	1.0	30.0h	30.0h
			90.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The course is hands-on oriented. Each student receives a package with several electronics parts and measurement equipment. The lectures are mostly interactive, meaning that the students build circuits and program their microcontroller under guidance of the lecturer. The parts are also needed for the regular homework assignments. Each student works on a small individual practical project in which a variety of the newly learned skills are applied.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Space Electronics 1 has graded assignments. The hardware kit is used to complete the assignments which are partially of hands-on nature.
In Space Electronics 2, the students work on a small electronics project either individually or in groups of two. The student demonstrates the project results by the end of the semester.
A 1 hour written test assesses knowledge that is covered in the theoretical lectures of Space Electronics 1 and 2.

Test elements	Categorie	Points	Duration/Extent
Test	written	40	1 hour
Project work	practical	30	30 hours
Assignments	flexible	30	30 hours

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Agarwal, A., Lang, J. H., Foundations of Analog and Digital Electronic Circuits, San Francisco, Elsevier, 2005.
Ley, W., Wittmann, K., Hallmann, W., Handbook of Space Technology., Chichester: John Wiley & Sons, Ltd, 2009.
Macdonald, M., Badescu, V., The International Handbook of Space Technology., Heidelberg: Springer, 2014.
Platt, C., MAKE Electronics, O'Reilly, 2009
Wiley, L. J., Wertz, J. R., Space Mission Analysis and Design., El Segundo: Microcosm Press, 2005.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Radiation Workshop

Module title:	Credits:	Responsible person:
Radiation Workshop	3	Avsar, Cem
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	cem.avsar@tu-berlin.de

Learning Outcomes

Space radiation has major effects on spacecraft and humans in space. The module introduces students to the sources, the characteristics, and the effects of space radiation. This knowledge is vital for space systems engineers who coordinate radiation test campaigns and plan technical measures for mitigating radiation effects.

After successful completion of this module, students will be able to
- classify the dose of space radiation in comparison to the radiation dose in daily life,
- recognize the technical terms and units that are relevant to working with radiation,
- explain the different sources and characteristics of space radiation,
- summarize the space radiation environment in common mission orbits,
- describe the general effects of space radiation on electronics,
- describe the effects of different space radiation types on the physical layer of electronics,
- select the relevant standards and processes for radiation testing,
- describe how to build radiation models and run a simulation of radiation effects using software tools,
- prepare a radiation test setup,
- interpret radiation test data,
- explain the basic principles of mitigating radiation effects.

Content

The following topics are addressed in this module:
- Radiation concept and units
- The space radiation environment
- Effects of space radiation on electronics
- Detailed TID effects in electronics
- Single Event Effects (SEE) in electronics
- Introduction to computational tools and calculation of radiation models
- Simulation of radiation effects on electronics
- Preparation of a total ionizing dose (TID) irradiation test setup with electronic components
- Hands-on radiation test campaign in a radiation chamber
- Basics of radiation effects mitigation

Module Components

Course Name	Type	Number	Cycle	SWS
Radiation Workshop	IV		WS	2

Workload and Credit Points

Radiation Workshop (Integrierte Veranstaltung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Exam preparation	1.0	15.0h	15.0h
Self-study of lecture materials	15.0	1.0h	15.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

The module starts with lectures that introduce the theory behind space radiation. It continues with a hands-on project in which the students conduct a radiation test campaign. The students prepare a small electrical circuit that is tested in a radiation chamber. The class is taken to a radiation chamber to learn about the facility, set up the test, and make measurements. The radiation test campaign results are interpreted and discussed in class.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the module Fundamentals of Space Technology
- Completed the module Space Electronics

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Schriftliche Prüfung	English	60 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:
Basics, reading material and seminars: https://www.radecs-association.net
Internal test reports and activities of ASTRIONICS GmbH
Simulations and basic concepts: https://www.spenvis.oma.be
Software and applications: https://www.trad.fr/en/space/omere-software
Standards: https://escies.org

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Spacecraft Dynamics and Control

Module title:	**Credits:**	**Responsible person:**
Spacecraft Dynamics and Control	9	Yoon, Zizung
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	zizung.yoon@tu-berlin.de

Learning Outcomes

The module provides the theory and practical application of spacecraft dynamics and control. The students learn all relevant elements for analyzing, designing, modelling and implementing an attitude control system.

After successful completion of this module, students will be able to:
- explain and interpret the basic terms and concepts of classical control theory,
- analyse the properties of linear systems,
- design controllers for linear systems,
- use standard software for the analysis of controlled systems and the design of controllers,
- explain and interpret the basics and methods related to state space control,
- derive the requirements for an attitude control subsystem from the mission objectives,
- explain the basic terms and concepts related to spacecraft attitude control,
- identify and calculate different methods for attitude parameterization and compare their advantages and limiting cases,
- identify and calculate/use different methods for attitude determination and their limitations,
- analyze the kinematics of attitude control and develop the kinematics model for a spacecraft,
- analyze the dynamics of a rigid body and develop the dynamics model for a spacecraft,
- model and demonstrate different spacecraft sensors and actuators,
- develop kinematics and dynamic models for a real system in three-axis,
- design and demonstrate single-axis attitude control maneuvers on a real system using the methods of classical control theory.

Content

- Properties and stability of linear systems
- Laplace transformation
- Classical control theory (Root locus, PID-controller, Nyquist)
- State space representation
- Basics and methods of state control (Pole Placement, Linear Quadratic Regulator, Observer)
- Model-based state prediction
- Mission analysis and requirements on attitude control systems
- Attitude control system concept and types
- Various types of spacecraft attitude parameterization
- Rigid body dynamics and attitude kinematics
- Attitude estimation algorithm

Module Components

Course Name	Type	Number	Cycle	SWS
Spacecraft Dynamics and Control 1	VL		SS	2
Spacecraft Dynamics and Control 2	VL		WS	4

Workload and Credit Points

Spacecraft Dynamics and Control 1 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Exam preparation	1.0	18.0h	18.0h
Assignments	6.0	2.0h	12.0h
Self-study of lecture materials	15.0	2.0h	30.0h
			90.0h

Spacecraft Dynamics and Control 2 (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Assignments	5.0	8.0h	40.0h
Project	1.0	30.0h	30.0h
Self-study of lecture materials	15.0	2.0h	30.0h
Exam preparation	1.0	20.0h	20.0h
			180.0h

The Workload of the module sums up to 270.0 Hours. Therefore the module contains 9 Credits.

Description of Teaching and Learning Methods

The module is divided into two parts, Spacecraft Dynamics and Control 1 and Spacecraft Dynamics and Control 2. The module starts with Spacecraft Dynamics and Control 1, where the basic concepts and methods of classical control theory, model-based state prediction, and state-space control are taught with relevant examples. Spacecraft Dynamics and Control 1 consists of theoretical lectures and homework.

The module continues with the second part, Spacecraft Dynamics and Control 2, where the students learn about the requirements for an attitude control subsystem, parameterization of spacecraft attitude, kinematics and dynamics of spacecraft attitude, and spacecraft attitude determination techniques. The students will then apply their theoretical knowledge of attitude dynamics and control theory in a hands-on project. In the project, single-axis attitude control maneuvers are implemented on a FloatSat (a satellite-like system with sensors and actuators that floats on an air-bearing table). Spacecraft Dynamics and Control 2 consists of theoretical lectures, homework, programming assignments, and group project work.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

No information

Test elements	Categorie	Points	Duration/Extent
Written exam	written	33	60 min
Homework	flexible	33	*No information*
Project	flexible	34	*No information*

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
available

Electronical lecture notes :
available

Recommended literature:

Dorf, Richard C., Modern Control Systems 12th ed. , Pearson
James Wertz, Spacecraft Attitude Determination and Control, Dortrecht 1991
Marcel Sidi, Spacecraft Dynamics and Control, Cambrindge Press, 2000
Markley, F. Landis, Crassidis, John L., Fundamentals of Spacecraft Attitude Determination and Control, Springer
Peter Berlin, Satelllite Platform Design, Kiruna 2005
Peter Hughes, Spacecraft Attitude Dynamics, Dover Publication Inc, 2004
Wiley Larson, James Wertz, Space Mission Analysis and Design, Dordrecht, 1999

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Spacecraft Propulsion Systems

Module title:	**Credits:**	**Responsible person:**
Spacecraft Propulsion Systems	6	Brieß, Klaus
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	klaus.briess@tu-berlin.de

Learning Outcomes

The module gives a technical overview of rocket and spacecraft propulsion systems. Students will understand the basic principles and system solutions for a large variety of propulsion technologies.

After successful completion of this module, students will be able to
- name and classify propulsion systems that are used in space projects,
- explain the principles physical principles of propulsion (e.g. Newton's laws, rocket equation, thrust, staging),
- recognize the application of propulsion systems for different orbital maneuvers,
- explain the working principles, technologies, challenges, and application areas of the most relevant types of propulsion systems (electric, solid, liquid, hybrid, airbreathing)
- explain the working principles and application areas of less conventional non-chemical propulsion systems,
- explain the classification, thermodynamic principles, characteristics, and application areas of space propellants,
- calculate the delta-v for space maneuvers,
- calculate the main parameters for the design of electrical propulsion systems (e.g. specific impulse, propellant mass, transfer duration),
- calculate the main parameters for the design of chemical propulsion systems (e.g. specific impulse, mass flow, nozzle parameters, propellant mass/volume, pressure, tanks),
- develop and draw the architecture of a chemical propulsion system.

Content

- Applications and classification of spacecraft propulsion systems
- Theoretical basics of rocket propulsion systems (e.g. fundamental rocket equation, staging, ascent trajectories)
- Characteristic parameters of space propulsion (e.g. thrust, impulse, velocity)
- Basics of orbital mechanics for spacecraft maneuvers
- Electric propulsion systems (e.g. electrothermal, resistojets, arcjets, electromagnetic, electrostatic)
- Other non-chemical propulsion systems (e.g. nuclear, launch assist, propellantless, gas, antimatter, space elevator, interstellar)
- Solid propulsion systems
- Hybrid propulsion systems
- Space propellants (e.g. liquid, solid, gel, green)
- Fundamentals of thermodynamics, gas dynamics, and nozzles
- Liquid propulsion systems
- Tank design and propellant feed systems
- Injection system
- Airbreathing propulsion systems (ramjet and scramjet)

Module Components

Course Name	Type	Number	Cycle	SWS
Spacecraft Propulsion Systems	VL		SS	4

Workload and Credit Points

Spacecraft Propulsion Systems (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Exam preparation	1.0	45.0h	45.0h
Self-study of lecture materials	15.0	2.0h	30.0h
Homework assignments	3.0	15.0h	45.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures in which the students are introduced to the fundamentals of propulsion systems.
Digital quizzes for each chapter support the students to evaluate their knowledge.

Homework assignments are provided in which the students execute selected design steps for the most relevant propulsion system types.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the module Fundamentals of Space Technology
- Completed the module Satellite Technology

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Mündliche Prüfung	English	30 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Alain Davenas, Solid rocket propulsion technology, Pergamon press, Oxford, 1993

F. A. Williams, M. Barrere, N.C. Huang, Fundamental aspects of solid propellant rockets, AGARD No. 116, Oct. 1969

Fortescue, P., Stark, J., Swinerd, G., Spacecraft System Engineering, Chichester, 2003.

International Reference Guide to Space Launch Systems, Isakowitz, Steven J., American Institute of Aeronautics and Astronautics, Inc., Reston, VA, London, Eurospan 2003. - 550 S.

Ley, W., Wittmann, K., Hallmann, W., Handbook of Space Technology., Chichester: John Wiley & Sons, Ltd, 2009.

P.H. Schmucker: Hybrid-Raketenantriebe, Goldmann, München 1972.

Raumfahrtsysteme : eine Einführung mit Übungen und Lösungen, E. Messerschmidt ; S. Fasoulas. - Berlin u.a.: Springer, 2000. 533 S.

Rocket propulsion elements, G. P. Sutton; O. Biblarz, 7. ed.,New York [u.a.] Wiley, 2001, 751 S.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Space Sensors and Instruments

Module title:	Credits:	Responsible person:
Space Sensors and Instruments	6	Brieß, Klaus
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	klaus.briess@tu-berlin.de

Learning Outcomes

The module introduces students to the concept of remote sensing including the relevant technologies and provides insights into image processing and its applications. The topic connects the technologies and physical principles on the payload-side with the processing and use of satellite data on the application-side. The knowledge and skills gained in this module are relevant for students with a career interest in developing remote sensing payloads, analyzing satellite data, and systems engineering.

After successful completion of this module, students will be able to
- describe the basic principles of remote sensing,
- summarize radiometric and photometric terms in remote sensing,
- identify the components and sample circuits of sensor electronics,
- explain different sampling concepts of optical sensors,
- describe aberrations of optical systems,
- name different types of lenses, telescopes, and filters,
- describe the working principles of different sensor types across the electromagnetic spectrum,
- describe data processing levels and calibration types,
- research and analyze relevant publications in any subtopic of remote sensing,
- apply data processing algorithms to satellite data,
- develop own algorithms to classify imagery/features,
- document code and research results in a journal-type report,
- manage interactions with people in an interdisciplinary and international team,
- present their work professionally within a project review.

Content

The module covers the basics of remote sensing with spacecraft. After covering the system-theoretical and electronic fundamentals, space sensors for gamma rays, X-rays, Ultra-Violet and visible light, for infrared and far-infrared radiation, and for microwaves are discussed. Calibration and ground data processing are elaborated finally.

- Introduction to Earth observation
- Electromagnetic waves
- Earth observation system theory
- Sensor electronics
- Gama-ray sensors
- UV and optical space sensor systems
- Infrared sensor systems
- Microwave sensor systems
- Sensor data processing
- Sensor calibration

Module Components

Course Name	Type	Number	Cycle	SWS
Space Sensors and Instruments	VL	3435 L 7270	WS/SS	4

Workload and Credit Points

Space Sensors and Instruments (Vorlesung)	Multiplier	Hours	Total
Project work	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	4.0h	60.0h
Attendance	15.0	4.0h	60.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of a theoretical lecture and seminars.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the module Fundamentals of Space Technology
- Completed the module Space Mission Planning and Operations
- Completed the module Satellite Technology

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

A group project is conducted in which the design and application of space sensors and instruments are in focus. The weekly group status reports, the final presentation and the project documentation are graded.

Test elements	Categorie	Points	Duration/Extent
Oral feedback	flexible	20	*No information*
Project presentation	flexible	40	30 min
Project documentation	flexible	40	*No information*

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	available

Recommended literature:

Elachi, Charles: Introduction to the physics and techniques of remote sensing / Charles Elachi. - New York [u.a.] : Wiley, 1987., 413 S.

Goodman, Joseph W.: Introduction to Fourier optics / Joseph W. Goodman. - 2. ed. . - New York, NY [u.a.] : McGraw Hill, 1996. 441 S.

Heinz Stoewer, Berndt P. Feuerbacher: Utilisation of Space, Springer, Berlin (Dezember 2005)

Jahn, Herbert: Systemtheoretische Grundlagen optoelektronischer Sensoren / Herbert Jahn ; Ralf Reulke. - 1. Aufl. . - Berlin : Akad.-Verl., 1995. - 298 S.

Kramer, Herbert J.: Observation of the earth and its environment : survey of missions and sensors ; with 857 tables. Herbert J. Kramer. - 4. ed. - Berlin: Springer, 2002. 1510 S.

Kreß, Dieter: Angewandte Systemtheorie : kontinuierliche und zeitdiskrete Signalverarbeitung / Dieter Kreß ; Ralf Irmer. - München [u.a.] : Oldenbourg, 1990. - 336 S.

Unbehauen, Rolf: Systemtheorie : Grundlagen für Ingenieure. München, Wien, Oldenbourg, 1990. 746 S.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Space System Design Project

Module title:	Credits:	Responsible person:
Space System Design Project	9	Ortega Varela de Seijas, Manuel
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	Manuel.ortega@mse.tu-berlin.de

Learning Outcomes

The space industry is demanding for space systems engineers capable of designing a space system from the basic requirements while having a robust knowledge of the project management, technical design, and product assurance disciplines. This module builds the skills to harmonize all engineering disciplines related to a space system design project, from a managerial and technical perspective. The module follows the European standards to project management, system analysis, reliability, and risk assessment as well as verification and testing strategies. The students actively apply the knowledge gained in the theoretical lectures on hands-on experience projects.

After successful completion of this module, students will be able to
- plan a space project in the phases B and C according to European standards,
- apply basic tools to conduct a preliminary design of a space mission (e.g. risk analysis, cost planning),
- document a space project according to European standards,
- discuss options for key decisions in space projects (e.g. make or buy, model philosophy, AIT approach),
- apply their fundamental space engineering knowledge and skills in a real space project,
- recognize the importance of managing technical interfaces between different work packages,
- manage their interactions with people in an interdisciplinary and diverse team,
- present their work professionally in space project reviews.

Content

- ECSS Project Management
- Baseline schedule, cost structure
- Organizational breadown structures, risk analysis
- Functional trees, design or buy (Technology Readiness Level)
- Reliability, Availability, Maintainability and Safety (RAMS)
- Configuration management plan
- Verification program and model philosophy
- Assembly, Integration and Testing (AI&T)
- Concurrent Design Facilities (CFD)

Module Components

Course Name	Type	Number	Cycle	SWS
Space System Design Project	VL		WS	4

Workload and Credit Points

Space System Design Project (Vorlesung)	Multiplier	Hours	Total
Self-study of lecture materials	15.0	2.0h	30.0h
Project work	15.0	8.0h	120.0h
Project documentation	1.0	40.0h	40.0h
Exam preparation	1.0	20.0h	20.0h
Attendance	15.0	4.0h	60.0h
			270.0h

The Workload of the module sums up to 270.0 Hours. Therefore the module contains 9 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures complemented by short assignments. To apply the theoretical content, students participate in a system design project. The project consists of developing a fully system. Participants are assigned to a specific subsystem, where they will analyse the mission objectives, develop requirements, evaluate alternative mission concepts, identify system drivers and describe the final mission architecture. The project is assessed through a mid-term review, a final review, as well as a final report.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the module Fundamentals of Space Technology
- Completed the module Space Mission Planning and Operations
- Completed the module Satellite Technology

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

A mid-term and final presentation about the system design project are held to assess the ability to apply the theoretical concepts. The documentation about the system design project evaluates the students' ability to document project work properly. In addition, a 1 hour written exam assesses the knowledge that is covered in the theoretical lectures.

Test elements	Categorie	Points	Duration/Extent
Project documentation	flexible	25	<10 pages
Final presentation	flexible	30	15 min
Midterm presentation	flexible	20	15 min
Written Exam	written	25	1h

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Elements of Spacecraft Design, C.D. Brown, AIAA, 2002
Space Mission Analysis and Design, W. Larson, J. Wertz, Kluwer, 1999
Space Project Management, ECSS-M-ST-10C standard, ECSS, 2009.

Assigned Degree Programs

This module is not used in any degree program.

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Space Technology Project

Module title:	Credits:	Responsible person:
Space Technology Project	9	Puttappa Nagalingesh, Vijay
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	vijay.pn@campus.tu-berlin.de

Learning Outcomes

The space industry is demanding for space systems engineers with hands-on experience. The module imparts the basics of the methodical detailed design and test of space equipment from a hands-on perspective. A focus is set on applying practical skills in mechanical, electrical, and software design in the scope of a space project. The students shall be able to design and test hardware and software on a component-, subsystem- or system level.

After successful completion of this module, students will be able to
- plan and execute a space project in the phases C and D according to European standards,
- apply basic software tools to design space equipment,
- document a space project according to European standards,
- apply their fundamental space engineering knowledge and skills in a hands-on project,
- recognize the importance of managing technical interfaces between different work packages,
- manage their interactions with people in an interdisciplinary and diverse team,
- present their work professionally in space project reviews,
- assemble, test, and verify space equipment.

Content

The module does not contain theoretical lectures but practically focuses on applying knowledge and skills from previous modules. Depending on the project's topic, introductory sessions about the project and additional required content may be provided. Highly relevant content like mechanical/electrical/software design, interface definition, project planning, testing, and more may be recapitulated depending on the focus of the project. The weekly attendance is mainly used to discuss the development status of the project and the next steps.

Module Components

Course Name	Type	Number	Cycle	SWS
Space Technology Project	VL		SS	4

Workload and Credit Points

Space Technology Project (Vorlesung)	Multiplier	Hours	Total
Project work	15.0	10.0h	150.0h
Attendance	15.0	4.0h	60.0h
Project documentation	1.0	60.0h	60.0h
			270.0h

The Workload of the module sums up to 270.0 Hours. Therefore the module contains 9 Credits.

Description of Teaching and Learning Methods

The topic of the hands-on project can differ and may include the development and test of a CubeSat subsystem, or else. The topic provides a real project context in which the students contribute to the research objectives of the Chair of Space Technology. The project is often performed in the scope of an experimental campaign, e.g. sounding rocket flight, stratospheric balloon flight, or else. The students are assigned individual tasks in a multidisciplinary team.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the module Fundamentals of Space Technology
- Completed the module Space Mission Planning and Operations
- Completed the module Satellite Technology
- Completed the module Space Electronics
- Completed the module Space System Design Project

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

A mid-term and final presentation about the system design project are held in which the students present the project status. The students document their work in a project report.

Test elements	Categorie	Points	Duration/Extent
Project documentation	written	40	<10 pages
Final presentation	flexible	40	15 min
Midterm presentation	flexible	20	15 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This module is not used in any degree program.

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Planetary Exploration and Space Robotics 1

Module title:	Credits:	Responsible person:
Planetary Exploration and Space Robotics 1	6	Avsar, Cem
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	cem.avsar@tu-berlin.de

Learning Outcomes

Humans use robotic systems to explore celestial bodies and to manipulate objects in space. This module introduces the basics of planetary physics, exploration of celestial bodies by robots, and in-situ resource utilization. The design, testing, and operation of robotic systems are addressed with a practical approach, using engineering models of robots in the scope of a hands-on project.

After successful completion of this module, students will be able to
- recognize basic terms used in planetary exploration and space robotics,
- name the applications of space robotics,
- give examples of space robotic systems,
- give examples of robotic space exploration missions,
- explain the working principles of the most relevant space robotics technologies in each subsystem,
- design a robotic system,
- explain the basic principles of machine perception,
- explain the basic principles of machine learning,
- explain the basic principles of navigation of mobile robots,
- describe the characteristics of the most relevant celestial bodies (e.g. Moon, Mars, asteroids, meteorites and comets),
- use the version control system Git to manage code in robotics projects,
- use the project management software Redmine,
- implement basic routines in Python for the purpose of controlling robots,
- use the Robot Operating System (ROS) for simulating robot behaviour,
- use the Robot Operating System (ROS) to control robots (e.g. navigation).

Content

- Basic terms in planetary exploration and space robotics
- Robotic space exploration missions
- Technology of planetary robots
- Machine perception
- Machine learning
- Navigation of mobile robots
- Asteroids, meteorites, and comets
- The Moon and in situ resource utilization
- The Mars and in situ resource utilization
- Version control with Git
- Introduction to Ubuntu
- Introduction Python
- Robot Operating System (ROS)
- Robot design project

Module Components

Course Name	Type	Number	Cycle	SWS
Planetary Exploration and Space Robotics 1	IV		WS	4

Workload and Credit Points

Planetary Exploration and Space Robotics 1 (Integrierte Veranstaltung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	2.0h	30.0h
Project work	15.0	6.0h	90.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures about planetary exploration and space robotics. Video lectures are used to introduce students to the variety of tools (e.g. Git, Ubuntu, Python, ROS) used in the scope of a robot design project. In the robot design project, students either design a new robot or expand the functionality of an existing robot. The project is on the level of a feasibility analysis and preliminary design, including prototyping if feasible.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Completed the course Fundamentals of Space Technology 1
- Completed the module Space Mission Planning and Operations

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

The project work is evaluated at defined milestones which consist of presentations and the final report.

Test elements	Categorie	Points	Duration/Extent
Final documentation	written	50	*No information*
Project status report	oral	20	15 min
Presentation	oral	30	20 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Recommended literature:

Alex Ellery: Planetary Rovers; Robotic Exploration of the Solar System. 2016. Published by Springer-Verlag Berlin Heidelberg. ISBN: 978-3-642-03258-5

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Planetary Exploration and Space Robotics 2

Module title:	Credits:	Responsible person:
Planetary Exploration and Space Robotics 2	6	Kryza, Lennart
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	lennart.kryza@tu-berlin.de

Learning Outcomes

This module covers the detailed design, prototyping and testing of a robotic system for a defined mission scenario. A given design problem will be solved by the students, mostly relying on results from Planetary Exploration and Space Robotics 1.

Content

- Detailed design of robot subsystems
- Project workflow
- Software design guidelines
- Team file management
- Testing and operation of robot systems

Module Components

Course Name	Type	Number	Cycle	SWS
Planetary Exploration and Space Robotics 2	IV		SS	4

Workload and Credit Points

Planetary Exploration and Space Robotics 2 (Integrierte Veranstaltung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	8.0h	120.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

Theoretical lectures, tutorials, demonstrations and project work

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Project work is evaluated at defined milestones.
Presentations about the project status are given.
A project documentation must be prepared.

Test elements	Categorie	Points	Duration/Extent
Final documentation	written	50	*No information*
Presentation	oral	30	20 min
Project status report	oral	20	15 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Alex Ellery: Planetary Rovers; Robotic Exploration of the Solar System. 2016. Published by Springer-Verlag Berlin Heidelberg. ISBN: 978-3-642-03258-5

Handbook of Space Technology

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Space Engineering (Master of Science)
- StuPO 2014
  - Modullisten der Semester: SoSe 2020

Miscellaneous

No information

Space Mission Planning and Operations

Module title:	**Credits:**	**Responsible person:**
Space Mission Planning and Operations	6	Ortega Varela de Seijas, Manuel
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	Manuel.ortega@mse.tu-berlin.de

Learning Outcomes

The space industry is demanding systems engineers who are capable of planning a space mission from project initiation to completion. This module introduces the programmatic aspects of space mission planning and operations. This involves acquiring a robust knowledge on the international standards and activities in astronautics. One focus of the module is set on gaining competencies in planning a space mission through its whole life cycle. Another focus is set on mission operations, which covers the theoretical aspects of ground stations and mission control structures, as well as handling procedures for mission operations.

After successful completion of this module, students will be able to
- identify the main elements of space mission planning and operations (e.g. user and mission concept analysis, data processing, archiving and distribution),
- explain the design steps to plan a space mission from project initiation to completion,
- apply the design steps of space mission planning on a project,
- develop a systematic approach to plan a project following international standards,
- justify design choices from a programmatic point of view,
- assess the feasibility of a space project,
- recognize the relevance of space laws in mission planning,
- select software tools that support the execution of space mission planning,
- describe the European space program (e.g. agencies, budgets, activities, facilities),
- explain the principles of creating a mission operations concept,
- recognize the main elements of a ground station,
- describe the traditional RF-telecommunication chain from ground to space, and vice versa.

Content

- Basics of space mission planning
- Introduction to ECSS standards
- Space activities of ESA, DLR, CNES
- Basics of space operations
- Satellite operations
- Regulatory aspects for space missions (space law)
- Ground station architectures
- Tools for space mission planning
- Project on mission design

Module Components

Course Name	Type	Number	Cycle	SWS
Space Mission Planning and Operations	VL		SS	4

Workload and Credit Points

Space Mission Planning and Operations (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Exam preparation	2.0	4.0h	8.0h
Self-study of lecture materials	15.0	2.0h	30.0h
Assignments	4.0	10.0h	40.0h
Project work	7.0	6.0h	42.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures and a small project where students need to plan a new space mission of their choice and evaluate its feasibility. Part of the course shows how mission operation tasks are conducted in a mission control room.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Short assignments to evaluate the understanding of the basic concepts within the lectures. A mid-term and final presentation about a space mission design project are held to assess the ability to apply the theoretical concepts (each 10 minutes including Q&A). The documentation (10 pages) about a space mission design project evaluates the students' ability to document project work properly. In addition, a 1 hour written exam assesses the knowledge that is covered in the theoretical lectures.

Test elements	Categorie	Points	Duration/Extent
Assignments	written	10	*No information*
Presentations	oral	30	10 min
Documentation	written	30	10 pages
Written Exam	written	30	1h

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Recommended literature:

Scholz, A., CubeSat Standards Handbook, The LibreCube Initiative, 2017.
Spagnulo, M., Fleeter, R., Balduccini, M., Nasini, F., Space Program Management - Methods and Tools, Springer, 2013.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Human Spaceflight

Module title:	Credits:	Responsible person:
Human Spaceflight	6	Ortega Varela de Seijas, Manuel
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	Manuel.ortega@mse.tu-berlin.de

Learning Outcomes

Human spaceflight is increasingly becoming a key driver in the world's total expenditure in the space domain, with many space agencies announcing the realization of future permanent crewed habitats on extra-terrestial environments. The module introduces students to the challenges and solutions of humans living and working in space from a technical and psychological aspect. Students start with the medical and psychological processes of adaptation to space environments, and continue with the module to build their engineering skills and design innovative strategies to mitigate the harsh space environment on humans.

After successful completion of this module, students will be able to
- identify the historical and future objectives of human spaceflight,
- describe the physiological factors that are relevant in human spaceflight,
- recognize the influence of the space environment on cognitive and psychomotor functions,
- give examples of mitigating the impact of the space environment on the human body and mind,
- recognize the technical and programmatic requirements to ensure humans can safely live and work in a space environment,
- factor in gender aspects in the development of crewed space systems,
- explain the technical working principles of elements of space habitats,
- develop a systematic approach to provide solutions for a human space habitat,
- apply the fundamental space engineering skills in a space project for human habitats,
- recognize the importance of managing interfaces between different work packages,
- manage the interactions with people in an interdisciplinary and international team.

Content

Technical Aspects of Human Spaceflight:
- History of crewed spaceflight
- Protection and mitigation against micro meteorites, micro-gravity, thermal environment, radiation
- Regenerative life support systems
- Human space law
- Space suits
- In-Situ Resource Utilization (ISRU)
- Analog studies

Space Psychology:
- Microgravity and changed day-night-cycle as specific stress factors of the space environment
- Physiological problems of adaption to zero-gravity (hear circular flow system, vestibular system, muscle and bone system, space sickness)
- Effect of microgravity on cognitive and psychomotor functions and performance
- Psychological effects of isolation and confinement on performance
- Mental stat and sozio-psychological processes within astronaut crews
- Psychological aspects of selection, training and support of astronauts

Module Components

Course Name	Type	Number	Cycle	SWS
Space Psychology	IV	0532 L 352	SS	2
Technical Aspects of Human Spaceflight	SEM	3534 L 858	SS	2

Workload and Credit Points

Space Psychology (Integrierte Veranstaltung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Self-study of lecture materials	15.0	4.0h	60.0h
			90.0h

Technical Aspects of Human Spaceflight (Seminar)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Project work	15.0	4.0h	60.0h
			90.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

In this module, the theoretical lectures of Space Psychology are complemented by group discussions and group work within the lecture time. The lectures of the Technical Aspects of Human Spaceflight are complemented by external guest seminars as well as with a project, which aims to design a new strategy or subsystem for humans to live and work sustainably in space.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

In the first semester, a test assesses the theoretical knowledge of the Space Psychology module. In the second semester, short ungraded multiple choice quizzes are conducted every 3 weeks to assess the theoretical knowledge of the Technical Aspects of Human Spaceflight module. In addition, students select a topic on each module, space psychology and technology, for which they prepare a presentation and documentation.

Test elements	Categorie	Points	Duration/Extent
Technical Aspects: Documentation	written	30	10 pages
Technical Aspects: Presentation	oral	30	20 min
Space Psychology: Written Exam	written	40	60 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Space Psychology: Kanas, N. & Manzey, D., Space psychology and psychiatry, Dordrecht: Springer, 2008.

Technical Aspects: IAA StudyGroup: The Next Steps In Exploring Deep Space - A Cosmic Study by the International Academy of Astronautics, 2004.

Assigned Degree Programs

This module is not used in any degree program.

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Introduction to Satellite Geodesy

Module title:	Credits:	Responsible person:
Introduction to Satellite Geodesy	6	Homakova, Olga
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://mse.tu-berlin.de	Englisch	olga.homakova@tu-berlin.de

Learning Outcomes

The module includes the fundamental principles of Satellite and Space Geodesy, such as geodetic, astrometric and astronomic reference frames and transformations, Earth Orientation, Satellite Orbit determination and introduces the most important space geodetic techniques: GNSS, VLBI, SLR, DORIS, Satellite Altimetry, InSAR and Gravity Field Satellite Missions. The main geophysical processes that cause changes of the antenna reference points are discussed as well, within a section on data analysis of space geodetic techniques. The students of space engineering will gain an initial overview of how Earth observing and navigation satellites as well as ground-based observatories can be used for current geoscientific and astrometric applications involving the analytical concepts of geodesy. The module consists of two parts, a lecture and the associated computer-based exercise, where the most important topics are further illustrated through practical examples.

Content

Conceptual basics of coordinate systems
Time scales
Terrestrial reference frames
Celestial reference frames
Earth orientation
Orbit determination
Space geodetic techniques: GNSS, VLBI, SLR, DORIS, satellite altimetry, spherical harmonics and gravity field, satellite-based gravity field determination, methods of space geodetic data analysis

Module Components

Course Name	Type	Number	Cycle	SWS
Introduction to Satellite Geodesy	VL	3534 L 8873	SS	4

Workload and Credit Points

Introduction to Satellite Geodesy (Vorlesung)	Multiplier	Hours	Total
Self-study of lecture materials	15.0	4.0h	60.0h
Homework	15.0	4.0h	60.0h
Attendance	15.0	4.0h	60.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

Lectures (50%)
Exercises (50%): 25% - theoretical introduction and preliminary discussion of the exercises, 50% - practical exercises /homework in groups of up to five students, 25% -homework debriefing

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Mündliche Prüfung	English	30 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Space Engineering (Master of Science)
- StuPO 2014
  - Modullisten der Semester: SoSe 2020

Miscellaneous

No information

Space Flight Mechanics

Module title:	Credits:	Responsible person:
Space Flight Mechanics	6	Brieß, Klaus
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	e.stoll@tu-berlin.de

Learning Outcomes

The module imparts knowledge in the basics of space flight mechanics. Space system engineers need the knowledge of space flight mechanics for different application areas in space mission design and analysis, and orbit and attitude control of a spacecraft. The engineering applications of space flight mechanics include the design of satellite orbits and interplanetary trajectories, rocket ascent trajectories, re-entry and landing concepts, rendezvous and docking maneuvers. Part of the outcome is the understanding of satellite orbit disturbances, different types of orbits, the basic laws of celestial mechanics, and time and reference systems. Further, a focus is set on introducing the programmatic aspects, thus developing the basic skills required to analyze and develop qualitative solutions for a real-life problem in the relevant application areas.

After successful completion of this course, students will be able to
- describe the characteristics of orbits, time and reference systems,
- explain the laws of celestial mechanics applicable to undisturbed satellite orbits,
- model gravitational and non-gravitational forces acting on an orbiting spacecraft,
- explain the influence of gravitational and non-gravitational forces on an orbiting spacecraft ,
- apply perturbation theory to develop qualitative solutions for a real space mission analysis and design problem,
- calculate the ground tracks using the orbital elements for a given orbit,
- explain the principles of relative motion applicable to the field of formation flight, rendezvous and docking,
- calculate the parameters of impulsive orbit maneuvers (e.g. delta-V, transfer time, and orbital elements),
- explain the basics terminologies and concepts of spacecraft re-entry.

Content

- Two-body problem
- Undisturbed satellite orbits
- Time and reference systems
- Gravitational and non-gravitational forces
- Perturbation theory
- Ground tracks and particular types of orbits
- Relative motion
- Impulsive orbit maneuvers
- Interplanetary trajectories
- Ascending trajectories
- Re-entry of spacecraft
- Applications

Module Components

Course Name	Type	Number	Cycle	SWS
Space Flight Mechanics	VL		SS	4

Workload and Credit Points

Space Flight Mechanics (Vorlesung)	Multiplier	Hours	Total
Self-study of lecture materials	12.0	5.0h	60.0h
Attendance	12.0	4.0h	48.0h
Exercises	12.0	4.0h	48.0h
Quizzes	12.0	2.0h	24.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures, quizzes, and homework exercises. During the exercises, solutions to different orbital mechanics problems are presented and discussed by students under supervision of the lecturers.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

Fundamentals of Space Technology
Satellite Technology
Spacecraft Dynamics and Control

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Mündliche Prüfung	English	*keine Angabe*

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
available	available

Recommended literature:

Fundamentals of Astrodynamics, Bate, R.R. et al, 1971
Fundamentals of Astrodynamics and Applications, Vallado, D.A., New York, 1997
Satellite Orbits, Montenbruck, O., Gill, E., Springer 2000
Understanding Space, Sellers, J.J., New, York, 1997

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Satellite Communication (SatCom)

Module title:	**Credits:**	**Responsible person:**
Satellite Communication (SatCom)	6	Lange, Sebastian
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	lange@tu-berlin.de

Learning Outcomes

Satellite communication is an essential part of all satellite missions. The numerous small satellites of TU Berlin offer a unique insight into this field. In the scope of this curricular project, the participants build ground station components within interdisciplinary teams. The course covers topics from radio communication and signal processing as well as electrical, mechanical and software engineering. Students will be able to summarize the working principles of hardware and software related to satellite communication. In combination with the knowledge and skills gained in other courses in space and electrical engineering, the participants will be able to set up a a satellite communication link. They will document and present their work at the end of the project.

After successful completion of this module, students will be able to
- work in an interdisciplinary project team,
- describe the general structure of satellite ground stations as well as their hard- and software components,
- organize small aerospace engineering projects,
- use open source soft- and hardware tools for management and development,
- recognize basic terms relevant for satellite communication,
- explain the architecture of a satellite link,
- use equipment for measuring the quality of a satellite link.

Content

- Applied technical know-how regarding satellite communications: e.g. characteristics of electromagnetic waves, components for transmitter and receiver circuits, antennas, transmission path, modulation and encoding schemes, operating modes, EMC, electronics, mechanics, programming, networking and other IT components etc.
- Practical hardware and/or software design as well as manufacturing and implementation
- Using electrical and RF measuring instruments and/or troubleshooting tools
- Methods for planning and organizing projects
- Technical and project documentation and presentation of the practical work

Module Components

Workload and Credit Points

Course-independent workload	Multiplier	Hours	Total
Project report	1.0	6.0h	6.0h
Attendance	14.0	3.0h	42.0h
Self-reliant project work and related outputs	14.0	8.0h	112.0h
Preparation of project presentation	1.0	20.0h	20.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

One or multiple projects in the field of satellite communication, partly chosen by the students itself, will be realized in structured teams. Each group or sub-team develops its part of the overall project and will be supported by experienced advisors. The basic knowledge needed to approach the project will be taught in a few lectures at the beginning of the course. In addition to this, students are required to extend their knowledge independently according to their assigned work package throughout the semester. The groups record their work in form of technical documents, a project report and present their results together in a final presentation.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- Space Mission Planning and Operations
- Satellite Technology

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

No information

Test elements	Categorie	Points	Duration/Extent
Project work (individual)	practical	30	*No information*
Project output (group)	flexible	40	*No information*
Final presentation (group)	oral	20	3-5 min per student
Project report (group)	written	10	2-5 pages

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

The maximum capacity of students is 6

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
There is an application process.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Recommended literature:

Elbert, Bruce R. Introduction to Satellite Communications. 3. ed. Boston, Mass. u.a.: Artech House, 2008.
Smith, Gould (WA4SXM). 2020 Edition of Getting Started with Amateur Satellites. AMSAT, 2020.
https://www.space.tu-berlin.de/menue/research/tubsat_missions/
https://wiki.satnogs.org/
https://gitlab.com/librespacefoundation/sdrmakerspace/sdreval/-/raw/master/Report/pdf/Evaluation_of_SDR_Boards-1.0.pdf

Assigned Degree Programs

This module is not used in any degree program.

Miscellaneous

Within the conceptual framework of the former meta-project "Space Interdisciplinary Engineering in Radio and Robotic Applications" (SIERRA) the focus is still on the interdisciplinary cooperation of the Chair of Space Technology and the Chair of High Frequency Technology, supported by the Amateur Radio Club of TU Berlin (AfuTUB / DK0TU).

Project Management

Module title:	Credits:	Responsible person:
Project Management	6	Homakova, Olga
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	olga.homakova@tu-berlin.de

Learning Outcomes

Space systems engineers plan project activities and manage technical teams. This module focuses on developing the practical skills required for the successful management of space projects.

After successful completion of this module, students will be able to
- differentiate between the various project management methods (linear, agile, hybrid) and assess them theoretically,
- structure projects according to the waterfall model (based on PRINCE 2 and PMBOK) (phase model),
- recognize the need for different roles in linear project management,
- evaluate, select and use instruments (e.g. Mind Map, Scamper, PESTEL, Stakeholder Analysis, WBS, Gantt Chart) in the relevant project phases,
- use different project management controlling instruments,
- use the Scrum method in the context of agile management methods and explain the entire process with its activities and roles,
- analyze the dynamics of a project team (Team Management System) and initiate measures to improve the team,
- assess international project teams and recognize and correctly evaluate various cultural phenomena.

Content

- Fundamentals of project management
- Factors of project success
- Project initiation phase and environmental scanning
- Work breakdown structure / analytic hierarchy process (AHP)
- Resources and time planning
- Risk management
- Project implementation
- Project management standards: PMI
- Leading a project team by using team management systems
- Equality in leadership and team work
- Basics of agile project management (Scrum)
- Scrum versus waterfall project management
- Controlling
- Team management systems
- Leadership in project calculation for project managers

Module Components

Course Name	Type	Number	Cycle	SWS
Project Management	VL		SS	4

Workload and Credit Points

Project Management (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	8.0h	120.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The module consists of theoretical lectures and business games as practical exercises. A group project is conducted in which the students apply the learned project management methods.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Group presentation: The teams which work together in the group project give a 20-minute presentation and submit a handout (6 pages).
Test: The course is concluded with a final test about the whole content of the lecture course.
Group assignment: Overall performance of the "companies", based on the financial results (Quicktest) and the final presentation of the business game TOPSIM, is evaluated.

Test elements	Categorie	Points	Duration/Extent
Group assignments	flexible	20	*No information*
Final presentation	oral	40	20 min
Test	written	40	90 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This module is not used in any degree program.

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Innovation Management and Entrepreneurship

Module title:	Credits:	Responsible person:
Innovation Management and Entrepreneurship	6	Homakova, Olga
	Office:	Contact person:
	No information	*No information*
Website:	Display language:	E-mail address:
http://mse.tu-berlin.de	Englisch	olga.homakova@tu-berlin.de

Learning Outcomes

Nowadays, technical knowledge is not the only competence necessary for a successful career. Many space start-ups are founded and large companies and agencies adapt to challenges using new methods of innovation management. This module introduced current key themes in innovation and entrepreneurship, including human-centered design and innovation eco-systems. This practical course will guide students to create new valued products, services or processes, from idea generation through to business concept development, testing, and presentation.

After successful completion of this module, students will be able to
- systematically explore, create and modify business-driven ideas,
- explain the human-centered design and innovation process to develop new products, services, or processes,
- validate assumptions and test prototypes,
- explain the innovation and business creation eco-system,
- transform new ideas into valuable solutions considering their impact,
- work in and lead interdisciplinary innovation project teams,
- present a concept in a pitch format.

Content

- Innovation processes and methods
- Innovation strategies
- Innovation and gender
- Business models
- Effectuation and entrepreneurial mindset
- Space related aspects of innovation and entrepreneurship
- Agile management

Module Components

Workload and Credit Points

Course-independent workload	Multiplier	Hours	Total
Attendance	15.0	4.0h	60.0h
Self-study of lecture materials	15.0	8.0h	120.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

- Lectures in form of short input sessions.
- Self-study of lecture material and via suggested and/or provided books, articles, videos, podcasts, blogs etc.
- Hands-on experimentation and feedback in groups and individually.
- Team projects and team presentations.
- Individual and group coaching.
- Engagement with innovation & entrepreneurship experts and topics.
- Preparation for presenting/pitching and coaching.
- Interaction with key innovation and entrepreneurship hubs in Berlin - could be technology centres, co-working spaces, etc.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Activity, engagement, experimentation and learning progress throughout the course is assessed.
The course is concluded with a final test about the whole content of the lecture course.

Test elements	Categorie	Points	Duration/Extent
Final presentation	oral	20	30 min
Group assignments	flexible	40	*No information*
Oral feedback	flexible	20	15 min
Team project documentation	written	20	*No information*

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations. Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

Soft Skills

Module title:	Credits:	Responsible person:
Soft Skills	3	Homakova, Olga
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://mse.tu-berlin.de	Englisch	olga.homakova@tu-berlin.de

Learning Outcomes

Skills in communication and social competence are key factors for prospective engineers seeking leading positions. The module will prepare students for the social challenges in the work environment and provide a basic understanding and a hands-on experimentation space for the key soft skills required to lead employees, teams and organizations. In immersive real-life situations, students will train and develop their abilities in teamwork, adaptability, collaborative problem solving, and other key transferrable soft skills.

After successful completion of this module, students will be able to
- describe required written, verbal, and non-verbal communication skills in globally diverse teams,
- actively listen and solve some typical conflicts in group engagement,
- describe team development phases and how they can effectively interact accordingly,
- collaborate, manage time and pro-actively develop themselves,
- apply critical observation and self-management skills to aid problem-solving and decision making,
- activate self-confidence to speak publicly with less fear and authentic presence.

Content

- Communication skills
- Culture map
- Teamwork and collaboration
- Active listening
- Critical observation
- Feedback and feedforward
- Storytelling
- Collaborative problem solving and decision making

Module Components

Workload and Credit Points

Course-independent workload	Multiplier	Hours	Total
Self-study of lecture materials	15.0	4.0h	60.0h
Attendance	15.0	2.0h	30.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

- Lectures in form of short input sessions.
- Self-study of lecture material and via suggested and/or provided books, articles, videos, podcasts, blogs etc.
- Hands-on experimentation and feedback in groups and individually.
- Team exercises.
- Individual and group coaching.
- Preparation for presenting/pitching and coaching.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None.

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
graded	Portfolioprüfung 100 points in total	English

Grading scale:

Note:	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
Punkte:	95.0	90.0	85.0	80.0	75.0	70.0	65.0	60.0	55.0	50.0

Test description:

Activity, engagement, experimentation and learning progress throughout the course is assessed.
The course is concluded with a final test about the whole content of the lecture course.

Test elements	Categorie	Points	Duration/Extent
Written test	written	90	90 min
Oral feedback	flexible	10	15 min

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This moduleversion is used in the following modulelists:

The course is limited to students from the Master of Space Engineering study programme.

Miscellaneous

No information

German for Engineers A1.1

Module title:	Credits:	Responsible person:
German for Engineers A1.1	3	Homakova, Olga
	Office:	**Contact person:**
	No information	*No information*
Website:	**Display language:**	**E-mail address:**
http://www.mse.tu-berlin.de	Englisch	olga.homakova@tu-berlin.de

Learning Outcomes

During and after their studies, MSE students are most likely to collect work experience in the German aerospace sector. The module German for Engineers is designed to help students to work in the engineering environment. The module A1.1 corresponds to basic users of the language, who communicate in everyday situations with commonly-used expressions and elementary vocabulary. After completing the A1.1 module, students can understand and use very frequently-used everyday expressions as well as simple phrases to meet immediate needs. They can introduce themself and others, ask and answer questions about personal details and interact in a simple way provided the other person talks slowly and clearly.

Content

- Introductions
- Talking about personal details such as where students live, things they have and people they know
- Gender and equality aspects in the German language and culture
- Counting
- Hobbies
- Ordering food, talking about food
- Expressing not having and needing things
- Talking about things
- Talking about what one can and cannot do
- Expressing prices
- Telling time
- Naming days of the week and months

Module Components

Course Name	Type	Number	Cycle	SWS
German for Engineers A1.1	UE	3534 L 819	SS	3

Workload and Credit Points

German for Engineers A1.1 (Übung)	Multiplier	Hours	Total
Attendance	15.0	3.0h	45.0h
Self-study of lecture materials	15.0	3.0h	45.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

- Individual work phases, couple and group work in classroom
- Interactive tasks for the development of speaking and writing skills and reading and listening comprehension
- Homework

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

None

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
ungraded	Portfolioprüfung 100 points in total	German

Grading scale:
At least 40 points in total needed to pass.

Test description:
No information

Test elements	Categorie	Points	Duration/Extent
Homework	flexible	1	20
Test	flexible	1	20

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

The maximum capacity of students is 12

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This module is not used in any degree program.

Master of Space Engineering

Miscellaneous

Prerequisite for a successful completion is the regular participation in the course (at least 80%).

German for Engineers A1.2

Module title:
German for Engineers A1.2
keine Angabe

Website:
http://www.mse.tu-berlin.de

Credits:
3

Office:
No information

Display language:
Englisch

Responsible person:
Homakova, Olga

Contact person:
No information

E-mail address:
olga.homakova@tu-berlin.de

Learning Outcomes

During and after their studies, MSE students are most likely to collect work experience in the German aerospace sector. The module German for Engineers is designed to help students to work in the engineering environment. The module A1.2 corresponds to basic users of the language, i.e. those able to communciate in everyday situations with commonly-used expressions and elementary vocabulary. After completing the A1.2 module, students can understand and use very frequently-used everyday expressions as well as simple phrases to meet immediate needs. They can introduce themself and others, ask and answer questions about personal details and interact in a simple way provided the other person talks slowly and clearly.

Content

- Talking about daily routine, work activities
- Making appointments
- Making directions
- Describing locations
- Talking about time and duration
- Talking about taste and preferences
- Naming body parts
- Naming items of clothing
- Talking about past using Perfekt
- Gender and equality in the German language and culture
- Expressing likes and dislikes
- Modal verbs

Module Components

Course Name	Type	Number	Cycle	SWS
German for Engineers A1.2	UE	3534 L 820	WS	3

Workload and Credit Points

German for Engineers A1.2 (Übung)	Multiplier	Hours	Total
Attendance	15.0	3.0h	45.0h
Self-study of lecture materials	15.0	3.0h	45.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

- Individual work phases, couple and group work in classroom
- Interactive tasks for the development of speaking and writing skills and reading and listening comprehension
- Homework

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

A1.1

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:
ungraded	Portfolioprüfung 100 points in total	German

Grading scale:
At least 40 points in total needed to pass.

Test description:
No information

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

The maximum capacity of students is 12

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This module is not used in any degree program.

Miscellaneous

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

German for Engineers A2.1

Module title:
German for Engineers A2.1
keine Angabe

Website:
http://www.mse.tu-berlin.de

Credits:
3

Office:
No information

Display language:
Englisch

Responsible person:
Homakova, Olga

Contact person:
No information

E-mail address:
homakova@campus.tu-berlin.de

Learning Outcomes

During and after their studies, MSE students are most likely to collect work experience in the German aerospace sector. The module German for Engineers is designed to help students to work in the engineering environment.
After completing the A2.1 module, students can understand sentences and frequently used expressions related to areas of most immediate relevance, communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters.

Content

- Introductions
- Talking about professions, education, CV
- Talking about daily routine
- Hobbies and lessure time
- Making appointments on the phone
- Reading short messages and notes
- Gender and equality in the German language and culture
- Reading messages and announcements at work
- Talking about frequency
- Talking about cause and effect (wenn-dann)
- Past time (Perfekt and Präteritum)
- Konjunktiv II
- Negation
- Verbs with prepositions

Module Components

Course Name	Type	Number	Cycle	SWS
German for Engineers A2.1	UE	3534 L 821	SS	3

Workload and Credit Points

German for Engineers A2.1 (Übung)	Multiplier	Hours	Total
Attendance	15.0	3.0h	45.0h
Self-study of lecture materials	15.0	3.0h	45.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

- Individual work phases, couple and group work in classroom
- Interactive tasks for the development of speaking and writing skills and reading and listening comprehension
- Homework

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

A1.2

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
ungraded	Schriftliche Prüfung	German	90 mins

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

The maximum capacity of students is 12

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	**unavailable**

Assigned Degree Programs

This module is not used in any degree program.

Miscellaneous

Prerequisite for a successful completion is the regular participation in the course (at least 80%).

German for Engineers A2.2

Module title:
German for Engineers A2.2
keine Angabe

Website:
http://www.mse.tu-berlin.de

Credits:
3

Office:
No information

Display language:
Englisch

Responsible person:
Homakova, Olga

Contact person:
No information

E-mail address:
olga.homakova@tu-berlin.de

Learning Outcomes

During and after their studies, MSE students are most likely to collect work experience in the German aerospace sector. The module German for Engineers is designed to help students to work in the engineering environment.
After completing the A2.1 module, students can understand sentences and frequently used expressions related to areas of most immediate relevance; communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters; describe in simple terms aspects of your background, immediate environment and matters in areas of immediate need.

Content

- Talking about travelling, countries, means of transport
- Talking about directions
- Giving recommendations (sollten)
- Describing people
- Describing items and comparing items
- Talking about plans and itinerarie
- Using the comparative and superlative
- Gender and equality in the German language and culture
- Talking about preferences
- Adjective declension
- Relative clause
- Accusative Prepositions

Module Components

Course Name	Type	Number	Cycle	SWS
German for Engineers A2.2	UE	3534 L 822	WS	3

Workload and Credit Points

German for Engineers A2.2 (Übung)	Multiplier	Hours	Total
Attendance	15.0	3.0h	45.0h
Self-study of lecture materials	15.0	3.0h	45.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

A2.1

Mandatory requirements for the module test application:

keine Angabe

Module completion

Grading:	**Type of exam:**	**Language:**	**Duration/Extent:**
ungraded	Schriftliche Prüfung	German	90 mins

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

The maximum capacity of students is 12

Registration Procedures

Registration at the MSE secretary according to the MSE study and examination regulations.
Dates and deadlines will be announced by semester start.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Assigned Degree Programs

This module is not used in any degree program.

Miscellaneous

Prerequisite for a successful completion is the regular participation in the course (at least 80%).