Course Description

Course title:	Applied physics
Neptun code:	GEFIT253MB-a, GEFIT253MBL-a (jó lesz???)
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 2p
Name and position of lecturer:	Gábor Pszota PhD, associate professor
Contact of lecturer:	gabor.pszota@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	4
Requirements (exam/practical mark/signature/report, essay):	exam
Course objectives (50-100 words):	The objective of the subject is to summarize the basic physical knowledge that students of the space engineering program will need. In addition, within the framework of the subject, the calculations related to the topics will also be practiced, after reviewing the theoretical background. Certain topics of Newtonian mechanics play a role in the movement of planets and spacecraft, as well as in the propulsion and control of the devices. Communication and operation are related to certain topics of thermography and electromagnetism. The description of electromagnetic waves is particularly important here, but to understand the sources emitting high-energy particles and photons, the topics of modern physics must also be reviewed. These topics include the principles of special and general relativity, as well as particle physics, which is necessary to understand the basic structure of matter. And radioactive decays, as well as nuclear fission and fusion, are important for current and future energy sources.

Course structure:	**Week**	**Topic**
	1.	Description of certain types of motion in different coordinate systems. Galileo transformations. Fundamentals of Newtonian dynamics, inertial and accelerating reference systems. Inertial forces.

2.	Description of free fall and projectile motion without and with air drag. Newton's law of gravitational force, orbits of planets and moons, Kepler's laws, orbits of satellites, orbit modification, ground track.
3.	Momentum theorem for mass points and mass point systems. The law of conservation of momentum and its application to rocket propulsion: calculation of thrust, terminal velocity.
4.	Mechanics of rotational motions, angular momentum theorem, law of conservation of angular momentum for mass points and mass point systems, description of gyroscopes, use of gyroscopes for orientation and maneuvering.
5.	Test 1
6.	Simple harmonic motion, damped oscillation and forced oscillation, resonance. Wave propagation and types, Doppler effect. Dependence of the speed of sound on pressure and temperature.
7.	Dependence of the hydrostatic pressure and density on altitude, mechanics of fluids, continuity equation, Bernoulli equation.
8.	1st and 2nd law of thermodynamics, types of heat propagation, heat conduction.
9.	Movement of charged particles in electric and magnetic fields, Earth's magnetic field, acceleration of particles, working principle of the ion engine, measurement of magnetic field and acceleration, Hall effect, piezoelectric materials.
10.	Maxwell equations, energy propagation in electromagnetic waves. The full electromagnetic spectrum (radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, gamma radiation). Methods of detection of the different ranges, photo effect.
11.	The principle of special relativity, Lorentz transformation, length contraction, time dilation, mass-energy equivalence, rest energy, kinetic energy of relativistic particles, solar wind and cosmic radiation. Methods for detecting high energy particles. The concept of dosage. Relativistic Doppler effect, speed measurement using radar.

	12.	The energy production and life cycle of stars, compact objects and their radiation, types of radioactive decay, nuclear fission and fusion. Use of radioactive isotopes for power generation, fission and fusion reactors.
	13.	Einstein's principle of equivalence, the principle of general relativity, gravitational waves and their detection, the structure and evolution of the universe.
	14.	Test 2.
Required readings:	Notes posted on the teacher's website for the course.	
Recommended readings:	1. Paul A. Tipler, Gene Mosca: Physics for scientists and engineers, Volume 1-3, W. H. Freeman, 2004 2. Paul A. Tippler / Ralph A. Llevellyn: Modern Physics. W. H. Freeman, 2012	
Evaluation method:	Signature and optional grade assigned based on the two tests. Additional written exam during the exam period where needed.	

Course Description	
Course title:	Applied mathematics
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 2p
Name and position of lecturer:	Attila Házy PhD, associate professor
Contact of lecturer:	attila.hazy@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	4
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	The aim of the course is to summarise the basic applied mathematical knowledge that students in aerospace engineering will need. The course will provide an overview of the theoretical background and will include practice in the calculations related to the topics. Numerical methods (approximate solutions, error estimation) and optimisation problems (conditional and unconditional, univariate and multivariate) play an important role in the life of engineers.	
Course structure:		
	2.	Introduction to Numerical Methods: approximate solutions of nonlinear equations (secant-method, Newton's method)
	3.	Approximate solutions of systems of linear equations (Jacobi method, Gauss-Seidel method)
	4.	Approximate solutions of systems of nonlinear equations (fixed point iteration method, Newton's method).
	5.	Optimization problems (convexity, extremal values of functions, general nonlinear optimization problems)
	6.	Approximate solutions to nonlinear optimization problems. Unconditional optimization, single variable cases. (Dichotomous method, golden section method, Fibonacci method, Newton-Raphson method)
	7.	Approximate solutions to nonlinear optimization problems. Unconditional optimization, multivariate case. (Newton's method, Modified Newton's method, the Gill-Murray algorithm and Levenberg-Marquardt method.)
	8.	Approximate solutions to nonlinear optimization problems. Unconditional optimization, multivariate case. (The Quasi-Newton methods, Newton-type optimization method with line search (BFGS (Broyden–Fletcher–Goldfarb–Shanno), DFP (Davidon-Fletcher-Powell)) methods)
	9.	Approximate solutions to nonlinear optimization problems. Unconditional optimization, multivariate case. (The Gradient method (or the Cauchy's method), Conjugate gradient method (Fletcher, Reeves))

	10.	Approximate solutions to nonlinear optimization problems. Unconditional optimization, multivariate case. SUMT (Sequential Unconstrained Minimization Technique)
	11.	Basics of optimization (Determination of extremal points and directions of a convex polyhedron)
	12.	Concept of linear programming, solution methods.
	13.	Simplex-method, duality problem. The concept of shadow price and how to determine it.
	14.	Sensitivity analysis of linear programming
Required readings:	S. Butenko, P. M. Pardalos: Numerical methods and optimization, an introduction. CRC press, A Chapman & Hall Books, 2008, (ISBN: 13: 978-1-4665-7778-7 (eBook - PDF))	
Recommended readings:	A. Házy: Numerical methods and optimization, https://web.uni-miskolc.hu/~matha	
Evaluation method:	Signature and optional grade assigned based on the two tests. Additional written exam during the exam period where needed.	

Course Description	
Course title:	Astrochemistry
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l
Name and position of lecturer:	Milán Szőri PhD, professor
Contact of lecturer:	milan.szori@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	2
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	Develop a comprehensive understanding of the origins of the universe, stars, and life. Explore the interdisciplinary connections between astronomy, chemistry, and biology. Gain knowledge of the tools and methods used in modern astronomy and astrobiology. Analyze the latest theories and discoveries related to the origin and evolution of life and the universe.	
Course structure:	**Week**	**Topic**
	1.	The origin of the molecular universe: the Standard Model - the Big Bang theory. The Standard Model - The Origin of the Universe.
	2.	The origin of life. Theories of the origin of life.
	3.	A brief introduction to cosmology: simple stellar models. Blackbody radiation. Cosmic microwave background radiation.
	4.	Stellar classification. Constellations. Galaxies.
	5.	Atomic and molecular astronomy: spectroscopy and the structure of matter. Line shape. Telescopes. Atomic spectroscopy.
	6.	Molecular astronomy. Molecular spectroscopy. Detection of hydrogen. Diffuse interstellar bands. Spectral mapping.
	7.	Stellar chemistry: classes of stars. Classes of stars. Herzprung–Russell diagram. Stellar evolution. Stellar spectra. Exotic stars. Cycle of star formation.
	8.	Interstellar matter: mapping molecular clouds. Molecules in the interstellar and circumstellar medium. Physical conditions in the interstellar medium. Rates of chemical reactions. Chemical reactions in the interstellar medium. Photochemistry. Chemistry of charged particles.
	9.	Interstellar matter: polycyclic aromatic hydrocarbons. Dust grains. Chemical models of molecular clouds. Prebiotic molecules in the interstellar medium.
	10.	Meteorite and comet chemistry: classification of meteorites. Chemical analysis of meteorites. The Murchison meteorite. Structure of a comet. Physicochemical relationships in the cometary coma. Chemical composition of comets. Cometary collisions. The Rosetta mission.

	11.	Prebiotic chemistry: carbon and water-based life forms. Spontaneous chemical reactions. The rate of chemical reactions. Endogenous formation of organic molecules. Exogenous delivery of organic molecules. Theories of chemical evolution. Homochirality. RNA-world hypothesis.
	12.	Primitive life forms: self-assembly and encapsulation. Protocells. The universal tree of life. Astrobiology?
Required readings:		(1) Andrew M. Shaw: Astrochemistry: from astronomy to astrobiology, 2006, John Wiley & Sons Ltd (ISBN-13: 978-0-470-09136-4) (2) Dieter Rehder: Chemistry in Space. From Interstellar Matter to the Origin of Life. 2010 Wiley-VCH Verlag & Co. (ISBN: 978-3-527-32689-1) (3) Stephan Schlemmer, Thomas Giesen, Harald Mutschke, and Cornelia Jäger (eds.): Laboratory Astrochemistry. From Molecules through Nanoparticles to Grains, 2015 Wiley-VCH Verlag GmbH & Co. (ISBN: 978-3-527-65316-4)
Recommended readings:		(1) Satoshi Yamamoto: Introduction to Astrochemistry. Chemical Evolution from Interstellar Clouds to Star and Planet Formation, 2017, Springer (ISBN 978-4-431-54171-4) (2) R. W. Schunk and A. F. Nagy Ionospheres. Physics, Plasma Physics, and Chemistry. Second Edition. 2009 Cambridge University Press (ISBN-13 978-0-521-87706-0)
Evaluation method:		Written exam

Course Description	
Course title:	Materials for spacecraft
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	3l, 1p
Name and position of lecturer:	Pál Bárczy CSc, professor emeritus
Contact of lecturer:	pal.barczy@admatis.com
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	4
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	The materials used in the components of satellites, space vehicles, and space missions perform special tasks. The subject summarizes the knowledge required for the selection, preparation and qualification of materials.		
Course structure:	**Week**	**Topic**	
	1.	1Structural vs functional materials definition and introduction. Bulk materials structure description (atomic level, microstructure, macrostructure). Surface description (atomic level, micro, macro level). Bulk materal properties, surface properties.	
	2.	Space environment description. Solid material – space environment interactions. Special interactions by launch, on orbit, by return. Electromagnetic radiation, particle flow, adsorption, emission, sublimaton. Material quarecteristics for interactions and cumulations: mass absorption cefficients, rad, Gray, Sv.	
	3.	The way from common material toward space material. Space technology R+D procedures. From TRL1 upto TRL9. Verification steps. Space technology competence tests. Tests in lab level. Integraton into subsystem. Technology demonstration in relevant environment. System proven in operational environment.	
	4.	Introduction to space mission planning. Conception, definition, design, implementation, launch, operation, wreck stations. Requirement lists for each equipments and parts of spacecraft at definition segment. Tasks by design and material selection. The verification matrix.	
	5.	Product assurance after ESA rules. Introduction into ECSS. The configuration, documentation, codification, communication, plan, report, review prescriptions. The witness sample. Rules for responsibility and confidentablity.	
	6.	Behavior and aging under space environment. Space exposure experimental results for selected material samples (NASA, ESA). Operational experiences. Simulation in Earth labs (AO tests, Sun-simulator tests, proton/neutron cannons, complex tests). Degradation of thermooptical	

	7.	Protective coatings. Surface treatment procedures. Insulating or conducting coatings. Paintings. Glues. Multi layered insulators. Radhard cover. KEPLA coat. Protective coatings for landing spacecrafts (SHS ceramics).
	8.	Thermal design of satellites assuring the thermal balance. Thermo optical behavior of materials. Insulators, thermal conductors. Radiators. Passíve and actíve thermal controls.
	9.	Metals for spacecrafts. Aluminum alloys. Titan alloys. Invar. Stainless steel. Materials for combustion chambers and nozzles. Composites for space missions: CFRP and GFRP. High tech polymers. PI, PEEK, Kapton. Vapor deposited polymers (K/VDA).
	10.	Cleanliness in space tech labs. Clean room. Clean bench. Cleanliness requirements for flight hardwares. Cleanliness and contamination control – ECSS-QST-70-01C. Particle contamination control...ESA PSS-01-204. Detection of organic contamination of surfaces by infrared spectroscopy ECSS-Q-ST-70-05C (clean bench + IR spectroscope)
	11.	Qualification devices in space industry. Bake out procedure. The TVC test procedure. Vibration test. Contact electrical resistance test. Roughness test. Humidity test. Ventil test. Grounding test. Wetting angle measurement. Incoming inspection.
	12.	Material failure inspection. Corrosion test. Contaminaton test. Painting failures (thickness, masking). Contrast problems. Dimension deviations (3D measurements)
Required readings:	1. A. Diebold, T. Hofmann: Optical and Electrical Properties of Nanoscale Materials, Springer International Publishing, ISBN:9783030803230 2. RICKY PEYRET: Handbook of Materials Science, NY Research Press, ISBN: 97816323857963. 3. Md Abdul Maleque: Materials Selection and Design, Springer Verlag, Singapore, ISBN: 9814560375	
Recommended readings:		
Evaluation method:		

Course Description	
Course title:	Materials Equilibria

Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l	
Name and position of lecturer:	György Kaptay DSc, professor	
Contact of lecturer:	kaptay@hotmail.com	
Prerequisite course(s):		
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/spring	
Number of credits:		
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	System, phase, component, mole fraction, phase fraction, materials balance, characteristics of the equilibrium state, state parameters, Gibbs energy, laws of thermodynamics, condition of global and heterogeneous equilibria, phase rule, one-component phase diagrams (construc-tion and interpretation), Gibbs energy of two-component mixtures and solutions, ideal solu-tion and their phase diagrams (their derivation and interpretation), solutions models and the 4th law, compound phases, two-component phase diagrams (their derivation, interpretation and classification).	
Course structure:	**Week**	**Topic**
	1.	1. Sturcture of science. Base quantities and base units. 2. Structure of atoms. Isotopes and elements. The number of stable elements. 3. Velocity, acceleration, force, energy, entropy. 4. The hierarchy of matter: system, phases, components, mole fraction and phase fractions and relations between them. 5. State parameters and their connections to the characteristics of equilibrium state, proper-ties of the system and satisfaction of customers.

2.	6. The initial state, the equilibrium state and states in-between (thermodynamics vs kinetics) 7. The number of combinations of state parameters and the time needed to perform all experiments. Why a method to calculate equilibrium of materials is needed. 8. The Gibbs energy the system. The general condition of equilibrium. 9. The integral Gibbs energy of phases and the partial Gibbs energy of the components.
3.	10. The condition of heterogeneous equilibrium. 11. Constituents of the Gibbs energy: the inner energy, the volume work and the entropy term. 12. Experimental methods and model description of the standard Gibbs energy of pure components as function of temperature and pressure. 13. Graphical derivation of one-component phase diagrams. 14. An Excel algorithm to calculate one-component phase diagrams
4.	15. Graphical derivation of one component phase diagrams with allotropes 16. Derivation of the phase rule 1: the maximum number of equilibrium phases 17. Derivation of the phase rule 2: fixed and free state parameters, and their meaning for one-component phase diagrams 18. The number of phase combinations.
5.	19. The pressure dependence of the melting point 20. The critical point and the difference between vapours and gases. 21. The four types of one-component phase diagrams for “solid”, “liquid”, “vapor” and “gaseous” phases at standard conditions 22. General issues on constructing phase diagrams for two-component systems. 23. The average integral Gibbs energy of mixtures and the integral Gibbs energy of solutions.

6.	24. The connection between partial and integral Gibbs energies (the tangent method) 25. The Gibbs energy of an ideal solution. 26. Construction of a binary phase diagram if a liquid solution is ideal, and if the solid phases have no mutual solubility (no allotropes, no compounds, different solid structures).
7.	27. Interpretation of the eutectic phase diagram: construction of the phase composition diagrams. 28. Interpretation of the eutectic phase diagram: construction of the phase ratio diagrams. 29. The equation for the liquidus line, which keeps equilibrium between pure solid phase alpha (and betha) and the ideal liquid A-B solution.
8.	30. The excel algorithm to construct the eutectic phase diagram: if a liquid solution is ideal, and if the solid phases have no mutual solubility (no allotropes, no compounds, differ-ent solid structures). 31. Construction of a binary phase diagram if both solid and liquid solutions are ideal (no allotropes, no compounds, identical solid structures): the solid solution type phase dia-gram.
9.	32. Equations for the equilibrium solidus and liquidus lines for a solid ideal A-B solution and a liquid ideal A-B solution. The excel algorithm to construct the solid solution type phase diagram (if both solid and liquid solutions are ideal (no allotropes, no com-pounds, identical solid structures). 33. Interpretation of the solid solution phase diagram: construction of the phase ratio dia-grams and the phase composition diagrams. 34. Concentration dependence of the excess Gibbs energy of solutions.
10.	35. Temperature dependence of the excess Gibbs energy of solutions (the 4th law). 36. Construction of solid phase separation line on phase diagrams, due to the repulsion of components within a solid solution phase. 37. The equations for the equilibrium separation line and the critical temperature for two solid solutions of the same structure but different compositions (the components re-pulse each other in the solid solution).

	11.	38. The equilibrium between a real solid solution and the ideal liquid solution. 39. The excel algorithm to calculate solidus and liquidus lines for the equilibrium of a real solid solution and an ideal liquid solution. 40. The graphical construction of the diagram with a minimum azeotropic point.
	12.	Test
	13.	41. The condition when a minimum azeotropic point appears. 42. The equations to find the coordinates of the azeotropic point. 43. The graphical construction of the eutectic phase diagram (same crystal structures, repul-sion between components).
	14.	44. The peritectic phase diagram without any azeotrope. 45. The peritectic phase diagram with the minimum azeotrope. 46. The topological diagram of possible phase diagrams as function of melting point difference between the components and their interaction energy in the solid state if the liquid solution is ideal (no compounds, no allotropes, crystal structures equal).

Required readings:	T.B.Massalski (ed): Binary Alloy Phase Diagrams, second ed., 3 volumes, ASM International, 1990. J.W.Gibbs: On the Equilibrium of Heterogeneous Substances, Trans. Conn. Acad. Arts Sci. 1875-1878, vol.3, pp.108-248, pp.343-524
Recommended readings:	Kaufman L, Bernstein H: Computer Calculation of phase diagrams (with special reference to refractory metals) - Academic Press, NY, USA, 1970, 334 pp. N.Saunders, AP Miodownik: CALPHAD, a Comprehensive Guide, Pergamon, 1998, 479 p Lukas HL, Fries SG, Sundman B: Computational Thermodynamics. The Calphad method. Cambridge University Press, 2007, Cambridge, UK, 313 pp.
Evaluation method:	oral exam

Course Description	
Course title:	Surface properties
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	3l,1p

Name and position of lecturer:	Peter Baumli PhD, professor	
Contact of lecturer:	peter.baumli@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/autumn	
Number of credits:	4	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	The aim of the course is to introduce students to the description and characterization of surfaces at the atomic level, with a focus on physico-chemical aspects. We will discuss the key mechanical, physical, and chemical properties relevant to surfaces, covering topics ranging from hardness to self-cleaning capabilities.	
Course structure:	**Week**	**Topic**
Lectures	**1.**	1. Definition and characterization of the surface
	2.	2. Interpretation of specific surface, effect on properties.
	3.	3. Interfacial properties, wetting, adhesion
	4.	4. Modification of the interface properties
	5.	5. Surface hardness, wear
	6.	6. Possibilities of surface hardening
	7.	7. Surface roughness and its effects
	8.	8. Optical properties of the surfaces
	9.	9. Optical coatings
	10.	10. Adsorption-desorption behavior of materials
	11.	11. Self-cleaning
	12.	12. Corrosion
	13.	13. Surface investigation techniques
	14.	14. Presentation of semester work
Practices	**1.**	1. Definition and characterization of the surface
	2.	2. Interpretation of specific surface, effect on properties.
	3.	3. Interfacial properties, wetting, adhesion
	4.	4. Modification of the interface properties
	5.	5. Surface hardness, wear
	6.	6. Possibilities of surface hardening
	7.	7. Surface roughness and its effects

	8.	8. Optical properties of the surfaces
	9.	9. Optical coatings
	10.	10. Adsorption-desorption behavior of materials
	11.	11. Self-cleaning
	12.	12. Corrosion
	13.	13. Surface investigation techniques
	14.	14. Presentation of semester work
Required readings:	A. Diebold, T. Hofmann: Optical and Electrical Properties of Nanoscale Materials, Springer International Publishing, ISBN:9783030803230 RICKY PEYRET: Handbook of Materials Science, NY Research Press, ISBN: 9781632385796 Md Abdul Maleque: Materials Selection and Design, Springer Verlag, Singapore, ISBN: 9814560375	
Recommended readings:	Surface Properties, Volume 95 Ilya Prigogine (Editor), Stuart A. Rice (Editor), ISBN: 978-0-470-14207-3	
Evaluation method:	The students prepare a semester project work. After the submission of the semester work, the teacher evaluates it. Accepted the semester work, the students can start the Oral examination.	

Course Description	
Course title:	Astronomy and Planetology
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	3l
Name and position of lecturer:	Norbert Zajzon PhD, associate professor
Contact of lecturer:	norbert.zajzon@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	During the semester, students gain insight into the scientific fields of astronomy, astrophysics and planetology. Education also emphasizes that, in addition to comprehensive knowledge, students acquire background knowledge that they can use in their further work. The basic instruments of astronomy will be introduced. After getting to know the structure and formation of the Universe and the Solar System, the topic focuses on the part of the Solar System closer to Earth (Moon, Mars, asteroids) and the rocks and materials available there, which is the most active field of space missions.	
Course structure:	**Week**	**Topic**
	1.	History of Astronomy. Spherical astronomy. Basics of solar mechanics. Two- and three-body issue. The trajectories of small Solar bodies. Satellites.
	2.	Astrophysics. HR-diagram. Born and evolution and final stages of stars. Star systems. Formation of the heavier elements of the Universe.
	3.	Galactical astronomy. Star clusters. The large structure of the Universe. Elements of cosmology.
	4.	Basics of astronomical instruments.
	5.	Solar astrophysics. The structure, energy production and evolution of the Sun.
	6.	Formation end evolution of the Solar system.
	7.	Basics of mineralogy and petrology.
	8.	Petrology of the meteorites.
	9.	Basics of geology and geological processes.
	10.	The Earth
	11.	Impact geology.
	12.	The formation, evolution, morphology and geology of the Moon.
		The Mars.
	13.	The elements of the Solar system. Earth type planets, giant planets. Small bodies of the Solar system.

Required readings:	Montanari A, and Koeberl C (2000): Impact Stratigraphy (The Italian Racord). Springer. French BA (1998): Traces of Catastrophe (A handbook of sochk-metamorphic effects in terrestrial meteorite impact structures). Lunar and Planetary Institute Contribution No. 954.
Recommended readings:	https://www.esa.int/ https://www.nasa.gov/
Evaluation method:	

Course Description		
Course title:	Knowledge of space quality and standards	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	3l,2p	
Name and position of lecturer:	Csaba Deák PhD, professor	
Contact of lecturer:	csaba.deak@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/spring	
Number of credits:	5	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	In the framework of the subject, students can learn about the international and domestic situation and legal background of the space industry. With the reliability and quality assurance requirements prescribed by each space agency, with the industry standards.	
Course structure:	**Week**	**Topic**
	1.	Hungarian and international environment of the space industry. Space research in Hungary. The European Space Agency (ESA). NASA (USA), RKA (Russia) and Eastern space industry. International space organizations: COPUOS, OSA, IAF, IAA, ISL.
	2.	Hungarian and international environment of the space industry. Space research in Hungary. The European Space Agency (ESA). NASA (USA), RKA (Russia) and Eastern space industry. International space organizations: COPUOS, OSA, IAF, IAA, ISL.
	3.	Specificities of the space industry - special requirements

4.	Basics of quality management, and management system standards. ESA PSS specifications
5.	Introduction to the ECSS standard system (ECSS-S-ST-00C) – Management (M), Product Assurance (Q) and Engineering (E) and their relationships.
6.	Description of nonconformity control system (ECSS-Q-ST-10 - Nonconformance control system)
7.	Quality assurance requirements for space projects, including requirements for test centers. (ECSS-Q-ST-20 - Quality Assurance)
8.	Demonstration of the reliability of the participants in the space segment. Including identification of any technical risks that may lead to non-compliance with reliability requirements (FMEA, FMECA), analyzes and design methods to ensure that reliability objectives are met, optimization of overall performance, costs and timing. (ECSS-Q-ST-30 - Reliability)
9.	Description of interactions between security and other programming and technical areas of space projects, activities supporting the process of security analysis and implementation. Hazard analysis, SDP, VTL. Review process. (ECSS-Q-ST-40 - Security)
10.	Required engineering activities, decision criteria for parts, identification of general risk areas about information sources. Manufacturer and part selection, Part approval and procurement, differentiation of quality levels, Radiation hardness assurance safety, Handling of non-standard parts, etc. (ECSS-Q-ST-60 - EEE parts)
11.	Space industry reliability considerations in the electronic design of spacecraft. Main parts of the 70 series of standards (ECSS-Q-ST-70 - Materials, mechanical components and processes, Purity and dirt control, Selection of materials for protection against stress corrosion cracking, etc.)
12.	Requirements for the development and maintenance of software for space systems (ECSS-Q-ST-80 - Software product assurance).
13.	Evaluation of projects through the TRL (Technology Readiness level) system. Requirements for each level.

Required readings:	Alexandru Georgescu, Adrian V. Gheorghe, Marius-Ioan Piso, Polinpapilinho F. Katina: Critical Space Infrastructures: Risk, Resilience and Complexity, Springer International Publishing, 2019, ISBN: 978-3-030-12603-2;978-3-030-12604-9
Recommended readings:	ECSS standards
Evaluation method:	od:- Active participation: 10%, - Group assignment (case studies and presentation): 50%, - W

Course Description		
Course title:	**History of Space Exploration and Space Industry**	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l	
Name and position of lecturer:	Zsolt András Udvarvölgyi PhD, dr. habil. college professor	
Contact of lecturer:	zsolt.udvarvolgyi@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/autumn	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):		
Course structure:	**Week**	**Topic**
	1.	Introduction. A Quick History of Space Exploration. The History of Space Exploration: a Timeline. The History of Space Exploration – A Short Documentary. The New Space Race of the 2020's (Documentary). Why SpaceX, Virgin, & Blue Origin Are Betting On Space Tourism. How China's space programme went from launching satellites to building its own space station. India Reveals Their Plan To Take Over Space. ESA.
	2.	Overview of recent space achievements. Motivations for space activity Major milestones. Services to the everyday life of many people on Earth. Space programmes of the other countries. Significant milestones in space exploration: From Sputnik (1957) to SpaceX Falcon 9 rocket (2024).

3.	Prelude to spaceflight: Precursors in fiction and fact. Konstantin Tsiolkovsky. Robert Goddard. Hermann Oberth. Other space pioneers. Early rocket development: Germany. Wernher von Braun V-2 rocket. United States. Soviet Union. Sergei Korolev (Korolyov). Preparing for spaceflight. Cold war. The International Geophysical Year.
4.	From Sputnik to Apollo. The first satellites. Sputnik 1. Explorer-1. Development of space organizations. United States: NASA. Soviet Union and Russian Federation: Roskosmos. Europe: European Space Agency. Japan. China: Tiangong Space Station. International participation. Involvement of industry.
5.	The first human spaceflights. Vostok 1. Gagarin and Tereshkova. Mercury. John H. Glenn. Gemini and Voskhod. Soyuz. The race to the moon. The American commitment. J. F. Kennedy. Soviet response. Interim developments. Project Apollo. N1 rocket. Apollo 11 mission: lunar landing, 20 July, 1969. Apollo-Soyuz test project, 1975.
6.	Orbiting space platforms. Space stations. Mir space station (1986-2001). International space station (1998-). International space endurance records. Summary of space stations launched since 1971. The space shuttle. The Challenger's catastrophe, 1986. The Columbia's disaster. Buran.
7.	Human beings in space: debate and consequences. SpaceX Dragon 2. Risks and benefits. Selecting people for spaceflight. Astronauts, cosmonauts, taikonauts. Biomedical, psychological, and sociological aspects.
8.	Science in space. Solar and space physics. Solar system exploration. Luna 1 and 3. U.S. Viking. China's Chang'e 3. Galileo spacecraft. Voyager 1 and 2. Cassini. New horizons space probe. Mars expeditions. Curiosity rover. Exploring the universe. Cosmic Background Explorer. Hubble Space Telescope. Microgravity research. Observing Earth. Space applications. Meteorology. Positioning, navigation, and timing. GPS. GLONASS. Galileo. Beidou and others.
9.	Military and national security uses of space. Satellite telecommunications. Intelsat 1. Project Kuiper. Remote sensing. Commercial space transportation. Falcon 9. New commercial applications. SpaceShipTwo.

	10.	Issues for the future. Planned missions of Artemis program. Space industry. A brief history of space industry. Segments within the space industry. Newspace: rebooting the space industry. Companies in the space industry that focus on space tourism: Virgin Galactic. SpaceX, Blue Origin, Boeing Starliner. Space tourism. How Space Tourism Will Work (documentary).
	11.	Hungary. Department for Space Activities of the Hungarian Ministry of Foreign Affairs and Trade. Hungarian space research. Bertalan Farkas, first Hungarian astronaut, 1980. HUNOR Program. Hungarian Space Kaleidoscope. Hungarian space industry
	12.	2024: A Pivotal Year for the Space Sector? Introduction. Ariane 6. Geopolitical trends. Economic and Technological Trends.
	13.	The future of space exploration. The future of space travel. Summary.
Required readings:	Almár, Iván- Both, Előd- Horváth András- Szabó, Attila: SH Atlasz. Űrtan. Budapest, Springer, 1996; Britannica: Space Exploration, downloadable; Wohrer, Paul: A Pivotal Year for the Space Sector? in: Briefings, DE L' IFRI, 2024., downloadable; Weinzierl, Matthew-	
Recommended readings:	Bromberg, Joan Lisa: NASA and the Space Industry. The John Hopkins UP, Baltimore and London, 1999.; NASA honlap; Horváth András- Szabó Attila: Űrhajózás-űrkutatás. Budapest, Közlekedési Múzeum, 1991. Horváth András- Szabó Attila: Űrkorszak. Budapest, Ekren, 2008.; Launius, Roger G.: The History of Space Exploration. London, Thames & Hudson, 2018.	
Evaluation method:	Oral exam	

Course Description	
Course title:	Space project management
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	3l
Name and position of lecturer:	Csaba Deák PhD, professor
Contact of lecturer:	csaba.deak@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	The course aims to provide students with comprehensive knowledge and practical skills in managing space-related projects. It covers the unique challenges and methodologies specific to space missions, including mission planning, risk management, cost control, and system engineering. Students will gain insight into international standards, legal frameworks, and the technological complexities associated with space exploration and satellite development. By the end of the course, students will be equipped to manage multidisciplinary teams and large-scale projects in the space industry.	
Course structure:	**Week**	**Topic**
	1.	Projects and project management in organizations.
	2.	Defining the scope of the project and feasibility studies
	3.	Time planning of the work devoted to the project, resource distribution
	4.	Cost estimate. Risk management
	5.	Analysis of project stakeholders
	6.	From the idea to the real business. Construction of projects (lean Start up) and startups
	7.	Half-term assessment
	8.	Project control. Project management with an agile approach
	9.-14.	ECSS – European Cooperation for Space Standardization. Life cycle planning in the space industry. Product definition, development, production, control, operation and disposal. Understanding the successive, interdependent processes: System requirement review, Preliminary Design review, Critical desig review, Test readiness review, Technical acceptance review
Required readings:	ECSS Document Tree and Status. (2021). Retrieved from ECSS Official Website: https://ecss.nl/standards/ecss-document-tree-and-status/ ECSS Members. (2021). Retrieved from ECSS Official Website: https://ecss.nl/organization/members/ ECSS-P-00C. (2013, 03 22). Retrieved from ECSS Official Website: https://ecss.nl/standard/ecss-p-00c-standardization-objectives-policies-and-organization-22march2013/	
Recommended readings:	Kriedte, Y. E. (1995). A New Approach to European Standards. Retrieved from ESA Bulletin: https://www.esa.int/esapub/bulletin/bullet81/krie81.htm	

Evaluation method:	Evaluation method:- Active participation: 10%, - Group assignment (case studies and presentation): 50%, - Written exam: 40%

Course Description		
Course title:	Space law and economics	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l	
Name and position of lecturer:	Anikó Raisz PhD, associate professor	
Contact of lecturer:	aniko.raisz@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/spring	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	International Space Law and Economy is a subject that leads the students into different dimensions of space law, namely into the fields of international public law, international private law and certain national legal systems, enabling them to become familiar with the legal environment relevant for a space engineer.	
Course structure:	**Week**	**Topic**
	1.	Introduction to International Public Law
	2.	Space Law in International Law
	3.	Space Law Treaties
	4.	The Principles of International Space Law
	5.	Space Law and the UN
	6.	Liability in Space Law
	7.	Environmental Questions
	8.	International cooperation
	9.	International Private Law Questions
	10.	Insurance Law
	11.	Strategy and Economic Actors
	12.	Space Law and Economy and the European Union
	13.	National Space Laws
	14.	Space Agencies

Required readings:	Stephan Hobe: Space Law. Baden-Baden: Nomos; München: C.H. Beck; Oxford: Hart Publishing, 2019, ISBN 978-3-8487-2487-1 (hardback Nomos) ISBN 978-3-406-69537-7 (hardback C.H. Beck) ISBN 978-1-5099-2409-7 (hardback Hart) ISBN 978-3-8452-6634-3 (Nomos ePDF)
Recommended readings:	Malinowska, Katarzyna: 'Risk Assessment in Insuring Space Endeavours: A Legal Approach'. Air & Space Law 42, no. 3 (2017): 329–348. Stephan Hobe: Protection of the Environment in Outer Space – Legal Considerations for Dealing with the Problem of Space Debris. In: Vasilka Sancin (ed.): International Environmental Law: Contemporary Concerns and Challenges, Zalozba, Ljubljana, 2012, pp. 73ff.
Evaluation method:	Signature and grade based on the exam. Potential written tasks during the semester.

Course Description	
Course title:	Space technology
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l
Name and position of lecturer:	György Czél PhD, professor
Contact of lecturer:	gyorgy.czel@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	2
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	The primary goal of the course is for the instructor to provide the students with knowledge about the technical conditions of research in microgravity space. The course, based on general engineering or physics knowledge, also provides detailed knowledge of space simulation and the closely related vacuum technology. The subject introduces the students in detail to the space equipment invented so far and the conditions of their operation. The subject of the course: The subject of the training is mainly space engineering material for students who wish to acquire engineering knowledge in the field of space materials technology. By mastering a semester's worth of educational material	
Course structure:	**Week**	**Topic**
	1-3.	the student gets to know the location of the near-Earth experimental compensation force field and the structure and energy supply of rockets, space shuttles and space stations are also described in the course material.
	4-5.	Special emphasis is placed on material technology heating equipment and high-temperature furnaces used in space.
	6-7.	The technique of the drop mine and drop tower as a micro-gravity scene is emphasized in the curriculum.
	8-9.	due to the space conditions in outer space, the description of the special application of the vacuum is also related to this subject.
	10-12.	In this way, students get to know the methods and importance of vacuum production, as well as the vacuum technologies still used in the plastics industry today.
	13-14.	In the course of learning the course material, the student also acquires knowledge about the surface preparation of non-metallic materials using vacuum technologies, vacuum steaming, vacuum etching, PVD surface treatment technologies, and biomaterials.
Required readings:	B. Feuerbacher, H.Hamecher, R.J. Naumann: Materials Science in Space	
Recommended readings:		
Evaluation method:		

Course Description	
Course title:	Vacuum physics and technology

Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 1p
Name and position of lecturer:	Sándor Bohátka CsC, senior research fellow
Contact of lecturer:	
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/spring
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam
Course objectives (50-100 words):	Knowledge necessary for the design, construction and operation of vacuum systems. Personal practice in the laboratory strengthens the knowledge of the students given during the lectures.

Course structure:	**Week**	**Topic**
Lectures	**1.**	all types and specific features of flows, pumping speed and throughput of pumps, conductance of pipes and openings and their calculation, series and parallel connection;
	2.	features of different vacuum ranges, processes and physical basis determining the ultimate vacuum of a vacuum system;
	3.	concept and necessity of „clean” (free of organic compounds) vacuum
	4.	different types, characteristics, operation and maintenance of pumps, especially considering the cleanliness of the vacuum produced;
	5.	types, features and operation of vacuum gauges;
	6.	operation of residual gas analysers, aim and method of their use;
	7.	leak tests of vacuum systems, localisation of leaks and quantitative determination of the leak flow (equipment and methods);
	8.	materials used in vacuum systems;
	9.	elements and accessories of vacuum systems;
	10.	operation of (ultra)high-vacuum (UHV) systems;
	11.	cleaning methods for use in vacuum technology;

		12.	the role and use of vacuum in analytical instruments for material science (e.g. X-ray Photoelectron Spectroscopy (XPS), Secondary Neutral Mass Spectrometry (SNMS), Scanning Probe Microscope (SPM)) and in magnetron sputtering process for thin film deposition.
	Laboratory practice	1.	The students get acquainted with the most important pumps, vacuum gauges, valves and other vacuum accessories as they are used in the everyday practice;
		2.	they assemble elements of vacuum systems and learn their maintenance;
		3.	from the given parameters of an ultrahigh vacuum system they calculate the necessary pumping speeds, decide the types and dimensions of the pumps, vacuum gauges and accessories to be used, and draw the block-diagram of the vacuum system;
		4.	they choose the main elements of the vacuum system constructed in the previous exercise;
		5.	they switch-on and operate a high vacuum system, practise venting and pump-down the vacuum chamber, then switch-off the system;
		6.	they operate a residual gas analyser (quadrupole mass spectrometer), determine the composition of the residual gases of a high vacuum system as a function of time, observe the outgassing of the wall of the vacuum chamber due to heating;
		7.	leak tests of a vacuum system with Pirani and ionization vacuum gauges as well as with residual gas analyser;
		8.	cleaning stainless steel construction elements.
Required readings:		Bohátka S., Csík A.: Laboratory practices in vacuum technique – instructions and guidance (megírandó) recommended literature: Bert Suurmeijer, Theo Mulder, Jan Verhoeven: Vacuum Science and Technology, The High Tech Institute & Settels Savenije van Amelsvoort NL, 2016, ISBN 978-90-9029137-6 Handbook of Vacuum Technology, edited by Karl Jousten, Viley-VCH GmbH and Co. KGaA, Weinheim, 2008.	
Recommended readings:			

Evaluation method:	

Course Description		
Course title:	Thermooptical properties	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l,1p	
Name and position of lecturer:	Helga Kovács PhD, associate professor	
Contact of lecturer:	helga.kovacs@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/spring	
Number of credits:	3	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	This course offers a comprehensive exploration of heat radiation principles and their application in space engineering. Students will gain in-depth knowledge of the fundamental concepts and advanced techniques necessary for analyzing and measuring radiation in various space environments. The course is designed for future space engineers and scientists who need to understand and apply radiative heat transfer principles in the context of space missions, satellite design, and planetary exploration.	
Course structure:	**Week**	**Topic**
Lectures	**1.**	Fundeamentals of heat radiation
	2.	Fundeamentals of heat radiation
	3.	Radiation intensity
	4.	Atmospheric and solar radiaton
	5.	Radiation heat transfer – view factor, black and grey bodies
	6.	Radiation Effect on Temperature Measurements
	7.	Radiation in gases
	8.	Radiation in gases
	9.	Optical radiation measurements
	10.	Radiometry
	11.	Optic radiometry
	12.	Photo and laser radiometry

	13.	The calibration and characterization of earth remote sensing and environmental monitoring instruments
	14.	The calibration and characterization of earth remote sensing and environmental monitoring instruments
Practices	1.	Heat radiation problems and calculations
	2.	Radiometry examples
	3.	Assigments
Required readings:		YUNUS A. ÇENGEL , AFSHIN J. GHAJAR : H E A T A N D M A S S T R A N S F E R, ISBN 978-0-07-339818-1 Franc Grum - OPTICAL RADIATION MEASUREMENTS, Volume 1, RADIOMETRY, ISBN 0 - 1 2 - 3 0 4 9 0 1 – 6
Recommended readings:		Barbara G. Grant: Field Guide to Radiometry, ISBN 978-0-8194-8827-5 Robert Celotta and Thomas Lucatorto : OPTICAL RADIOMETRY, ISBN: 0 12 475988 2
Evaluation method:		Written exam

Course Description	
Course title:	Material property design
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 1p
Name and position of lecturer:	Peter Baumli PhD, professor
Contact of lecturer:	peter.baumli@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	The aim of the subject is to describe the properties and production of nanodispersed systems. In the case of properties, great emphasis is placed on learning about interface phenomena and their interpretation for specific nano-dispersed systems. In the second part of the course, we cover the production methods, clarification of grinding, chemical reduction methods, sol-gel procedures, etc. The knowledge task of the subject partially covers the investigation of nano-disperse systems as well. The literature research-based mid-year project allows to delve deeper into a specific topic.	
Course structure:	**Week**	**Topic**
	1.	Structure of materials, chemical bonds, their properties
	2.	Structure of crystalline materials
	3.	Characterization of amorphous materials
	4.	Design of mechanical properties
	5.	Modification of hardness and wear properties
	6.	Thermal expansion properties and design
	7.	Thermal conductivity and design
	8.	Design of electrical properties
	9.	Design of radiation-related material properties
	10.	Examination and modification of surface properties
	11.	Melting point modification options
	12.	Design of corrosion properties
	13.	Design of magnetic properties
	14.	Presentation of semester project
Required readings:	A. Diebold, T. Hofmann: Optical and Electrical Properties of Nanoscale Materials, Springer International Publishing, ISBN:9783030803230 RICKY PEYRET: Handbook of Materials Science, NY Research Press, ISBN: 9781632385796	
Recommended readings:	Md Abdul Maleque: Materials Selection and Design, Springer Verlag, Singapore, ISBN: 9814560375	
Evaluation method:	The students prepare a semester project work. After the submission of the semester work, the teacher evaluates it. Accepted the semester work, the students can start the Oral examination.	

Course Description

Course title:	Measurement technology
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2p
Name and position of lecturer:	Tamás Mikó PhD, senior research fellow
Contact of lecturer:	tamas.miko@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	2/autumn
Number of credits:	2
Requirements (exam/practical mark/signature/report, essay):	practical mark
Course objectives (50-100 words):	Measurement technology is a subject of fundamental importance for all engineering courses, within the framework of which students get to know all the knowledge necessary for the construction, assembly and operation of modern measuring systems and the interpretation and documentation of measured values. By completing the course, the student is able to design and select the most suitable measurement systems for the given purpose in the case of the most common and important measurements used in the space industry. These include measuring temperature, geometry, displacement, force, pressure/vacuum, resistance, and various surface properties of materials. Using the knowledge acquired during the course, the student will be able to properly process, analyze and record the data collected during the measurements according to the relevant space industry standards.

Course structure:	**Week**	**Topic**
	1.	Basic units (SI) used during measurements
	2.	Standards used during (aerospace) measurements
	3.	General structure of measuring systems
	4.	Data collection and data processing
	5.	Documenting, storing and communicating measured data (Protocol preparation)
	6.	Construction and operation of load cells
	7.	Distance and displacement measuring systems
	8.	Possibilities of temperature measurement

	9.	Measurement of electric voltage and resistance
	10.	Pressure and negative pressure (vacuum) measurement
	11-14.	individual work
Required readings:	ECSS-E-10-02 ECSS-E-10-03	
Recommended readings:		
Evaluation method:		

Course Description		
Course title:	Thermological, strength and dynamic simulation	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l, 2p	
Name and position of lecturer:	Peter Bencs PhD, associate professor	
Contact of lecturer:	peter.bencs@uni-miskolc.hu	
Prerequisite course(s):	Applied matemathics	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/spring	
Number of credits:	4	
Requirements (exam/practical mark/signature/report, essay):	practical mark	
Course objectives (50-100 words):	Space equipment (satellites, rockets, etc.) must endure even extreme loads, drastic temperature differences, electromagnetic radiation and excitations that change over time. Numerical analysis of such time-varying tasks usually indicates nonlinear behavior. The course aims to demonstrate the modeling of these effects, using different commercial software.	
Course structure:	**Week**	**Topic**
	1.	Fundamentals of the mechanics of material point, rigid bodies and fluids.
	2.	Kinematic and kinetic considerations, momentum equation. Balance equations, the First and Second Law of Thermodynamics.
	3.	Heat conduction, heat transfer and heat radiation.
	4.	Basics of numerical modeling. Demonstration of commercially available software.

	5-6.	Demonstrate the calculation of stationary heatless and heat source conduction with a selected commercial program through an application example.
	7.	Numerical modelling of an unsteady heat conduction and heat transfer problem.
	8.	Modelling the effect of heat radiation in space through specific examples.
	9.	Introduction to nonlinear finite element analysis.
	10.	Modelling simple examples using the finite element method.
	11.	Large deformation, displacement and rotation.
	12.	Nonlinear material models. Case studies: to determine dents, collisions, critical loads.
	13.	Eigenvalue tasks, modal analysis.
	14.	Harmonic vibration, spectrum analysis. Random vibrations.
Required readings:	K. J. Bathe, "Finite Element Procedures," Prentice-Hall, Englewood Cliffs, 1996. J. Tu, G.H. Yeoh, C. Liu, Computational Fluid Dynamics: A Practical Approach, Butterworth-Heinemann, Elsevier Publication, 2018.	
Recommended readings:	RAJPUT, R. K. Engineering thermodynamics: A computer approach (si units version). Jones	
Evaluation method:	Grades assigned based on the two tests.	

Course Description		
Course title:	Cleanroom technologies	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l, 1p	
Name and position of lecturer:	Csaba Dücső PhD, senior research fellow	
Contact of lecturer:	ducso.csaba@ek-cer.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	1/autumn	
Number of credits:	3	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):		
Course structure:	**Week**	**Topic**

Lectures	**1.**	Cleanrooms-I. - Its purpose, classification, structure, technical solutions, standard services
	2.	Clean rooms – II. - Specific purposes, operation and quality control of clean rooms used in the space industry
	3.	Micro- and nanotechnologies – I. - Thin film detachments
	4.	Micro- and nanotechnologies – II. - Image designs
	5.	Micro- and nanotechnologies – III. - Layer removal; Micromechanics: 2D-3D micromachining, sensors: 1 time Short references to "Back end processing", assembly technology
	6.	Solar panels
	7.	Effects of impurities - Effects of contaminants on spacecraft, planetary protection
	8.	Manufacturing, assembly, device and satellite integration, testing
	9.	Cleanliness and Contamination Control transportation of space hardware cleaning, related logistics challenges
	10.	Major foreign and domestic space technology centers, clean room assembly plants, ESTEC, assembly halls for large satellite integrators
	11.	Basics of electron microscopy
	12.	Basics of radiation protection
Practices	**13-14.**	Electron microscope + nanolithography: lecture + presentation together
	13-14.	PRESENTATION - Laboratory visit to EC clean rooms (microtechnology and space)
	13-14.	The practices can be done on the same day, in 4-6 hours in total
Required readings:	US FED STD 209Esz standard ISO 14644-1 standard	
Recommended readings:	GMP-EU standard	
Evaluation method:		

Course Description	
Course title:	Space mining and raw material processing
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l

Name and position of lecturer:	Zoltán Virág PhD, associate professor
Contact of lecturer:	zoltan.virag@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	2/autumn
Number of credits:	2
Requirements (exam/practical mark/signature/report, essay):	exam
Course objectives (50-100 words):	A celestial body (asteroid, comet, planet moon) that can hide valuable raw material for us and this object is captured on the way, or possibly "dragged" into the gravitational field of the Earth/Moon, and then extracted raw material that can be transported back to Earth or used there. The most basic methods in industry, such as blast mining, surface mining, deep cultivation and borehole mining, may also be feasible in the case of space mining, but not in the same form as on Earth. Innovative methods of raw material processing, differences in raw material processing in terrestrial, planetary and asteroid space, and the enabling technologies in the technical and economic context. Social impacts of space mining.

Course structure:

Week	Topic
1.	Introduction to mining
2.	Winning methods and technologies: Underground mining equipment
3.	Winning methods and technologies: Open-pit mining equipment
4.	Blasting technology for mining
5.	Haulage equipment
6.	Continuous conveying
7.	Reporting on space mining
8.	Mineral processing on Earth
9.	Processing properties of minearl deposits
10.	Processing characterisation of planetary and asteroid based resources
11.	Mineral processing in space
12.	Space manufacturing
13.	Project work

	14. Reporting on space processing and manufacturing
Required readings:	Howard L. Hartman, Jan M. Mutmansky: Introductory Mining Engineering, John Wiley & Sons, 2002, ISBN 0471348511, 9780471348511 Peter Darling: SME Mining Engineering Handbook, Society for Mining, Metallurgy & Exploration, Incorporated, 2011, ISBN 0873354540, 9780873354547 W. Durst, W. Vogt: Bucket wheel excavator, Trans Tech Publications, 1988, ISBN 0878490752, 9780878490752 Conveyor Equipment Manufacturers Association: Belt conveyors for bulk materials, Conveyor Equipment Manufacturers Association (CEMA), 2014, ISBN 1891171445, 9781891171444 Bhalchandra V. Gokhale: Rotary Drilling and Blasting in Large Surface Mines, CRC Press, 2010, ISBN 0203841395, 9780203841396
Recommended readings:	Gour C. Sen: Blasting Technology for Mining and Civil Engineers, UNSW Press, 1995, ISBN□86840294X, 9780868402949 Davide Sivolella Space Mining and Manufacturing Off-World Resources and Revolutionary Engineering Techniques Springer Praxis Books, 2019, ISBN 978-3-030-30880-3
Evaluation method:	Oral exam, grade 1-5

Course Description	
Course title:	Solidification and Gravity
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 1p
Name and position of lecturer:	Zsolt Veres PhD, associate professor
Contact of lecturer:	zsolt.veres@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam

Course objectives (50-100 words):	Students will learn the fundamentals of the solidification of pure metals and solid solutions. They will learn about the nucleation (homogenous and heterogenous) and growth of grains by pure metals, solid solutions, eutectic alloys and peritectic alloys. They learn about the more important solidification technologies and the methods to influence the mechanical properties of the workpieces through the solidified microstructure.	
Course structure:	**Week**	**Topic**
	1.	Phase diagrams
	2.	Foundry alloys, solidification phenomena, thermal parameters
	3.	Structure of the liquids, nucleation
	4.	Planar solidification, change of the solid-liquid interface, the structure of the ingots
	5.	Microsegregation
	6.	Dendritic solidification
	7.	Porosity
	8.	Eutectic solidification
	9.	Macrosegregation
	10.	Additív manufactury
	11.	Peritectic solidification
	12.	Solidification path in multicomponent systems
	13.	Hot tearing
	14.	Solidification technologies
Required readings:	Kurz W.: Fundamentals of Solidification Dantzik J.A., Rappaz M.: Solidification Stefanescu D.M. : Science and Engineering of Casting Solidification	
Recommended readings:	Glicksman M. E. : Principles of Solidification Flemings M.C.: Solidification processing	
Evaluation method:	Oral exam, grade 1-5	

Course Description	
Course title:	Material knowledge, degradation
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core

Lecture/ Seminar (practical); hours per week:	2l, 1p
Name and position of lecturer:	Valéria Mertinger DSc, professor
Contact of lecturer:	valeria.mertinger@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	1/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	exam
Course objectives (50-100 words):	The behavior of materials in addition to the effects they experience during delivery into space and operation in the space environment. The causes and phases of changes in the properties of materials and the destruction of materials, and planning with them. Methods and procedures used during the examination of the deterioration process.

Course structure:	**Week**	**Topic**
Lectures	**1.**	Impact methods
	2.	Mechanism of failure of materials micro scale
	3.	Mechanism of failure of materials at macro scale
	4.	Material specific failure modes
	5.	Reliability analysis
	6.	Accelerated life tests
	7.	Methods of failure analysis non-destructive I
	8.	Methods of failure analysis non-destructive II
	9.	Methods of failure analysis destructive I
	10.	Methods of failure analysis destructive II
	11.	Case studies I
	12.	Case studies II
	13.	Inquiry
Practice	**1-2.**	Non-destructive testing
	3-4.	Destructive tests I
	5-6.	Destructive tests II
	7-13.	Individual exercise
	14.	Presentation

Required readings:	Editor(s): Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei,Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries,Butterworth-Heinemann,2016,Pages 57-73,ISBN 9780128009505, ASM HAndbook vol. 11 Failure analysis and prevention, ASM International, 2002, ISBN 0-87170-704-7 William D. Callister Jr., David G. RethwischMateria Science and engineering : An introduction 10 th kiadás, 2018, ISBN: 978-1-119-40549-8
Recommended readings:	
Evaluation method:	

Course Description		
Course title:	Material selection	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l, 1p	
Name and position of lecturer:	Csaba Póliska PhD, associate professor	
Contact of lecturer:	csaba.poliska@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/spring	
Number of credits:	3	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	Material selection taking into account the effects of the space environment and the purpose of the task. The most important material science characteristics of the types of materials used in space vehicles (metallic, intermetallic, ceramic, polymer, composite, nano- and intelligent materials). Design for earth and space environments: vacuum, radiation, microgravity, extreme temperature fluctuations, vibration, impurities, meteorites, space debris. Patents. Surface protection of space tools. Case studies - analysis of the best-known failures from a materials science point of view.	
Course structure:	**Week**	**Topic**
	1.	Introduction. Space missions, carriers, satellites, space stations (MIR, ISS)

	2.	Earth environment – Atmospheres
	3.	Space environment and its effects – vacuum, radiatons, contaminants, meteoroids and space debris
	4.	Basics of material science in space - Mass and heat transport, diffusion, wetting, combustion, chemical reactions, thermal conductivity
	5.	Materials in space – Metals and alloys
	6.	Materials in space – Ceramics and glasses
	7.	Materials in space – Polymers
	8.	Materials in space – Composites
	9.	Surface protection – coating, insulations
	10.	Written test
	11.	Case studies – failure analysis from a material science perspective
	12.	Patents, standards
	13.	Presentation of the semester research assignments
	14.	Secondary written test
Required readings:	Protection of materials and structures from space environment, edited by Jacob I. Kleiman and Zelina Iskanderova. 2003 Springer Science + Business Media, Inc. & Kluwer Academic Publishers. Print ISBN: 1-4020-1690-5 Pisacane, Vincent L.: The space environment and its effects on space systems. American Institute of Aeronautics and Astronautics Education series, 2008. ISBN 978-1-56347-926-7 Barrie D. Dunn: Materials and Processes for Spacecraft and High Reliability Applications, 2016 Springer International Publishing Switzerland, ISBN 978-3-319-23361-1, DOI 10.1007/978-3-319-23362-8	

Recommended readings:	Advances in Space Research, Elsevier (https://www.journals.elsevier.com/advances-in-space-research) Advanced Space Engineering – Frontiers in Space Technologies (https://www.frontiersin.org/journals/space-technologies/sections/advanced-space-engineering) International Journal of Astronomy and Astrophysics, Scientific Research Publishing (www.scirp.org/journal/ijaa) Recommended webpages: The European Space Agency (ESA): https://www.esa.int/Education National Aeronautics and Space Administration (NASA): https://www.nasa.gov/
Evaluation method:	Written test, grade 1-5. Grading scale: >90 %: excellent, 80-89 %: good, 65-79 %: medium, 50-64 %: satisfactory, <50 %: unsatisfactory.

Course Description		
Course title:	Precision machining	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2p	
Name and position of lecturer:	Viktor Molnár PhD, associate professor	
Contact of lecturer:		
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/spring	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	practical mark	
Course objectives (50-100 words):		
Course structure:	**Week**	**Topic**
	1.	Introduction. Basic concepts of precision machining.
	2.	Conventional and new materials used in components of space equipment (metallic materials) and their production methods.
	3.	Conventional and new ceramics and polymers used in components of space equipment and their production methods.

	4.	Overview of the conventional and new manufacturing technologies applied in the space industry for precision components.
	5.	5-axes machining.
	6.	Micro-machining technologies and procedures.
	7.	Nano-machining technologies and procedures.
	8.	Lithographic technologies and procedures.
	9.	Overview of the recent additive machining procedures.
	10.	Accuracy-influencing factors of precision machined components.
	11.	Measuring methods of precision machined components (application of high-accuracy measuring equipment and machines).
	12.	Surface quality-influencing factors of precision machined components.
	13.	Measuring and analysing methods and equipment of precision machined components.
	14.	Components and measuring methods of surface integrity.
Required readings:	Wit Grzesik: Advanced Machining Processes of Metallic Materials, Elsevier, Amsterdam, 2017, ISBN: 9780444637116. J. Paulo Davim: Machining – Fundamentals and Recent Advances, Springer, 2008, ISBN: 9781848002122. Kai Cheng – Dehong Huo: Micro-Cutting – Fundamentals and Applications, Wiley, 2013, ISBN: 9780470972878.	
Recommended readings:	David Dornfeld – Dae-Eun Lee: Precision Manufacturing, Springer, New York, 2008, ISBN: 9780387324678. Mark J. Jackson: Micro and Nanomanufacturing, Springer, New York, 2007, ISBN: 9781441938459.	
Evaluation method:		

Course Description	
Course title:	Construction design
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core

Lecture/ Seminar (practical); hours per week:	2l	
Name and position of lecturer:	Ferenc Sarka PhD, associate professor	
Contact of lecturer:	ferenc.sarka@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/spring	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	practical mark	
Course objectives (50-100 words):	The aim of the course is to familiarize students with the typical forms of damage to machine components, including fatigue caused by time varying load. In the following, the operational characteristics of the two most typical machine elements exposed to fatigue (gear drives, rolling bearings) will be described. The subject presents their typical forms of damage and the possibilities of protection against them.	
Course structure:	**Week**	**Topic**
	1.	Effect of material structure changes on service life (corrosion, stress corrosion cracking, thermal and radiation embrittlement).
	2.	Effect of contact conditions on service life (wear, surface fatigue, fretting). Wear laws, wear speed. Effect of lubricants and coatings.
	3.	Operability of structural elements with cross-sectional defect. Treatment of cracked structural elements, crack propagation, determination of remaining service life.
	4.	Service life, creep concept, stages of structures operating at elevated temperatures. Sizing options for creep damage. Determination of life expectancy
	5.	Task and classification of transmissions. Operation of machines and machine groups. Belts, toothed belts and chain drives.
	6.	Classification of toothed element pairs. Designations. Geometry and derivation of spur gear-pairs with straight and helical toothing, external and internal toothing, and bevel gears with intersecting axles.
	7.	Fundamentals of geometry and strength dimensioning of toothed element pairs.

	8.	Special transmissions. Gear efficiency and losses. Noise and vibration of gears.
	9.	The task of bearings, their classification. Typical operating conditions of rolling bearings. Typical operating conditions of plain bearings.
	10.	Life of rolling bearings under variable load and variable speed. Lubrication of rolling bearings.
	11.	Examples of installation of rolling bearings, both on the shaft and in the housing. Specifications for interfaces.
	12.	Damage of rolling bearings. The relationship between the image of damage and the cause.
	13.	Test
	14.	Repeated test
Required readings:		Alan F. Liu: Structural life assessment methods. ASM International, Materials Park, Ohio, 1999. p. 419 Szendrő Péter (szerk.): Gépelemek, Mezőgazda kiadó, 2007 SKF: Bearing Maintenance Handbook, 2011, ISBN 978-91-9789-66-4-1
Recommended readings:		Muhs, Wittel, Jannasch, Voßiek: Roloff/Matek Machinenelemente, Vieweg Verlag, 2013 Shaeffler Technologies AG & Co: Wälzlagerpraxis – Handbuch zur Gestaltung und Berechnung von Wälzlagerungen. ISBN 978-3-7830-0401-4, Westermann Druck, Zwickau. 2015.
Evaluation method:		written test, grade 1-5

Course Description	
Course title:	Space qualification tests
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	3l
Name and position of lecturer:	Pál Bárczy CSc, professor emeritus
Contact of lecturer:	pal.barczy@admatis.com
Prerequisite course(s):	-
Language of the course:	English
Suggested semester: autumn /spring, 1-6	2/autumn
Number of credits:	3

Requirements (exam/practical mark/signature/report, essay):	practical mark	
Course objectives (50-100 words):	Flight hardwares have to meet requirements. The conformity to requirement specifications is proved by the qualification procedure. The qualification procedure is prescribed by ECSS-E-10-03. The aim of the subject is to learn the test procedures of flight hardwares.	
Course structure:	**Week**	**Topic**
	1.	Verification procedures ECSS-E-10-02
	2.	Testing ECSS-E-10-03: Equipment level, subsystem level, system level. Equipment qualification tests.
	3.	Physical properties measurements
	4.	Functional and performance test
	5.	Humidity test
	6.	Leakage test, pressure test
	7.	Constant acceleration test
	8.	Sinusoidal vibration test
	9.	Random vibration test
	10.	Acoustic test
	11.	Shock test
	12.	Thermal vacuum test
	13.	Thermal cycling test
	14.	Life test
Required readings:	ECSS-E-10-02 ECSS-E-10-03	
Recommended readings:		
Evaluation method:		

Course Description	
Course title:	Soldering, gluing
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	2l, 1p
Name and position of lecturer:	Tamás J. Szabó PhD, associate professor
Contact of lecturer:	tamas.szabo@uni-miskolc.hu
Prerequisite course(s):	-
Language of the course:	English

Suggested semester: autumn /spring, 1-6	2/autumn
Number of credits:	3
Requirements (exam/practical mark/signature/report, essay):	practical mark
Course objectives (50-100 words):	The course explains in detail the most common joining techniques of soldering and gluing. It gives an insight of the used materials for both the traditional Lead based and the limited use in aeronautics lead free soldiers (no brazing as it is naot space compliant) and the specifics for electronics preparation and the execution of the soldering. We also discuss common and spe-cial glues and adhesives, their theory and practical application. The course Explains the che-mistry and physics of the bond formation, and mechanisms. Detailed discussion is presented about the processes occurring during joining and the methods of testing of the adhesives and the joints, especially under the specific requirements of aeronautical and space operations.. Through examples we can evaluate the potential errors, their causes and practical ways to avoid them.

Course structure:	**Week**	**Topic**
	1.	Introduction to the course discussion of the semester, grading timetable; discussing the hazards (chemical) of using adhesives and solders and mechanical/thermal hazards, electronic hazards and the usage of equipments and tools for making joints and testing them
	2.	Introduction to jointning and joints
	3.	Common issues, Surface preparation
	4.	Discussion of soldering
	5.	Soldering materials and technologies applicable for aeronautics and space
	6.	Testing of soldered joints
	7.	Discussion of adhesive joints
	8.	Types of adhesives by bonding, chemistry and application
	9.	Testing of adhesive joints
	10.	Handing out writing intensive hand in work sample preparation, Quizz
	11.	Adhesive joining of test samples
	12.	Solder joining of test samples/ soldering
	13.	Testing of joints

	14.	Summary / repeat quizz
Required readings:	Anthony J. Kinloch: Adhesion and Adhesives: Science and Technology Sina Ebnesajjad, Arthur H. Landrock: Adhesives Technology Handbook David Lammas: Adhesives and Sealants (Workshop Practice) SRA Solder, Samuel G. Skinner: How to Solder Electronics: 15 Rules for Successful Soldering: Essential Knowledge for Producing Reliable Solder Joints (SRA Solder Guides)	
Recommended readings:		
Evaluation method:		

Course Description		
Course title:	Space-borne Remote Sensing	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	1l, 1p	
Name and position of lecturer:	Endre Dobos PhD, associate professor	
Contact of lecturer:	endre.dobos@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/autumn	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	practical mark	
Course objectives (50-100 words):	The aim of the course is to summarize the theoretical background of space-borne remote sensing and to review the major fields of applications.	
Course structure:	**Week**	**Topic**
	1.	Basic concepts and physical background of remote sensing
	2.	Passive remote sensing techniques (satellite remote sensing based on electromagnetic radiation)
	3.	Active remote sensing techniques (radar, LiDAR, sonar)
	4.	Remote sensing applications I. (mapping and determining the situation)
	5.	Remote sensing applications II. (meteorology, oceanography)
	6.	Remote sensing applications III. (Geological and geomorphological mapping, raw material survey)

	7.	Remote sensing applications IV. (Soil mapping, precision agriculture)
	8.	Getting to know more important satellite families, databases and data systems
	9.	GIS tools for remote sensing data processing and analysis I. (Introduction to raster based GIS)
	10.	GIS tools for remote sensing data processing and analysis II. (Map, preprocessing of satellite images)
	11.	GIS tools for remote sensing data processing and analysis III. (Classification procedures I.)
	12.	GIS tools for remote sensing data processing and analysis IV. (Classification procedures II.)
	13.	Exam
	14.	Exam repetition opportunity for unsuccesful exams
Required readings:		Adams, John: Remote sensing of landscapes with spectral images: a physical modeling approach. Cambridge University Press, Cambridge, 2006. ISBN: 0521662214,9780521662215 Levin, Noam: Fundamentas of Remote Sensing. Remote Sensing Laboratory, Geography Department, Tel Aviv University, Israel. 1999. Elachi, Charles –van Zyl, Jakob: Introduction to the Physics and Techniques of Remote Sensing. Wiley-Interscience, 2006. ISBN: 0471475696,9780471475699,9780471783381
Recommended readings:		Nayak, Shailesh – Zlatanova, Sisi: Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters. Springer, 2008. ISBN: 9783642098154,3642098150 Campbell, James B. –Wynne, Randolph H.: Introduction to Remote Sensing. Guilford, 2011. ISBN: 9781609181765,160918176X
Evaluation method:		

Course Description	
Course title:	Applied geophysical and data processing methods in space exploration
Neptun code:	
Type (core, specialization, optional, dissertation, other):	core
Lecture/ Seminar (practical); hours per week:	1l, 1p
Name and position of lecturer:	Norbert Peter Szabó DSc, professor

Contact of lecturer:	norbert.szabo@uni-miskolc.hu	
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/autumn	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):	The aim of the course is to summarize the theoretical background of geophysical surveying and data processing methods and to review the relevant fields of applications.	
Course structure:	**Week**	**Topic**
	1.	Measurable physical properties of the Earth and the planets of the Solar System.
	2.	Fundamentals of raw material exploration (applied) geophysical methods.
	3.	Surface, airborne and satellite survey systems.
	4.	The gravitational and magnetic exploration method.
	5.	Generation of a three-dimensional potential function of a gravitational field.
	6.	Magnetic properties of the planets in the Solar System.
	7.	Fundamentals of electrical and electromagnetic methods.
	8.	Seismic methods. In-situ borehole geophysical (well-logging) techniques.
	9.	Processing and interpretation of measured data.
	10.	Data processing methods based on Fourier analysis of time series and deterministic, stochastic filtering.
	11.	Geophysical methods of subsurface (planetary) structure exploration, inverse modeling.
	12.	Possibilities of using multivariate statistical procedures, machine learning and artificial intelligence.
	13.	Processing of planetary geophysical and other space data.
	14.	Case studies from geophysical research and exploration of different planets in the Solar System.

Required readings:	Philip Kearey, Michael Brooks, Ian Hill (2013): An Introduction to Geophysical Exploration. Third edition. Wiley-Blackwell. Serra O. & L., 2004. Well logging data acquisition and application, Editions Technip. Szabó N. P., 2015. Geophysical exploration methods I. Electronic textbook. Szabó N. P., 2016. Well-logging methods. Electronic textbook.
Recommended readings:	Telford W. M., Geldart L. P., Sheriff R. E., 1990. Applied geophysics. Second edition. Cambridge University Press.
Evaluation method:	Type of assessment: Attendance at lectures is regulated by the university code of education and examination. Two writing tests with satisfactory results during the semester is the requirement of signature. Grading scale: >86 %: excellent, 71-85 %: good, 61-70 %: medium, 46-60 %: satisfactory, <45 %: unsatisfactory.

Course Description		
Course title:	Communication in space systems	
Neptun code:		
Type (core, specialization, optional, dissertation, other):	core	
Lecture/ Seminar (practical); hours per week:	2l	
Name and position of lecturer:	János Bitó PhD, associate professor	
Contact of lecturer:		
Prerequisite course(s):	-	
Language of the course:	English	
Suggested semester: autumn /spring, 1-6	2/autumn	
Number of credits:	2	
Requirements (exam/practical mark/signature/report, essay):	exam	
Course objectives (50-100 words):		
Course structure:	**Week**	**Topic**
	1.	Overview - Satellite Systems Overview, Basic Concepts, Regulations, Allocated Frequency Bands

2.	Baseband signal: general block diagram of the communication system (e.g.: source/sink, encoder/decoder, modulator, channel) and multiple methods; Digital baseband signal: time division system data rate calculation and required bandwidth determination, digital modulation and data rate, bandwidth, BER, Eb/No, and C/N determination (e.g.: OOK, QPSK, N-QAM)
3.	Satellite orbits and orbital methods (GEO and LEO), Satellite orbit and position calculation (azimuth - elevation, distance between satellite and ground station)
4.	Space segment: structure and specifications of communication satellites (GEO and LEO), Presentation and parameter calculation of antenna types used on satellites
5.	Ground Segment: Structure of ground stations; Presentation and parameter calculation of antenna types used in earth stations
6.	Structure and operation of terrestrial satellite tracking systems
7.	Radio wave propagation I .: propagation models (atmosphere, cloud, rain, etc.)
8.	Radio wave propagation II .: rain attenuation (fading); transmission disturbances: effect of polarization, depolarization, and scintillation on transmission
9.	Radio wave propagation III.: Interference effect, visibility, latency, and delay; Interference determination, reserve calculation
10.	RF channel calculation I .: received power calculation, noise determination (for cascade system), determination of reception signal-to-noise ratio, determination of required transmit power; uplink and downlink channel C/N calculation, CINR and reliability
11.	RF channel calculation II .: composite channel C/N calculation; intermodulation noise, channel calculation between satellites
12.	Characterization of multiple access channels, calculation uplink and downlink power requirements (TDMA, FDMA, CDMA)
13.	Satellite Communications Networks and Services (FSS, BSS, MSS), current technical solutions, and future technical developments; Reliability of satellite systems and services;
14.	HTS - mega-constellations, FSO - Deep space communication; Disturbance of satellite systems

Required readings:	Dennis Roddy, "Satellite Communications," 2006, McGraw-Hill Companies, Inc. ISBN 0-07-146298-8 L. J. Ippolito, "Satellite Communications Systems Engineering," 2008, Wiley Ltd. ISBN 978-0-470-72527-6 G. Maral, M. Bousquet, "Satellite Communications Systems," Wiley Ltd. ISBN 978-0-470-71458-4
Recommended readings:	G. Maral, "VSAT Networks" Wiley Ltd. ISBN 0-470-86684-5 T. Pratt, J. E. Allnutt "Satellite Communications," Wiley Ltd. 978-0471370079 ITU: R-REC-P.618-x, R-REC-P.676-x, R-REC-P.838-x, R-REC-P.838-x, ... (in force) ETSI: ETSI EN 301-545-2; ETSI TS 102 188-6c
Evaluation method:	