

*Federal State Autonomous Educational Institution of Higher Education  
Peoples' Friendship University of Russia  
Academy of Engineering*

**COURSE SYLLABUS**

**Educational program**

01.04.02 «Applied Mathematics and Computer Science /  
Прикладная математика и информатика».  
Специализация «Space Mission and System Design /  
Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>French for Foreign Students / Французский язык как иностранный</i>
<b>Scope of discipline</b>	<b>6 CU (216 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Spheres and situations of communication. Domestic sphere of communication	Casual, educational, socio-cultural and professional vocabulary. Situations potentially possible in the professional sphere of communication
Themes and problems of communication. The educational-cognitive sphere.	Mutual understanding. Communication in the family/workplace. Speech etiquette. Private conversation. Taboo aspects of communication in different cultures. Multilingualism in the modern world/country/region/ in study group. Personal experience of language learning. Working in an office. Establishing contacts with employees.
Socio-cultural environment. Types of texts for teaching receptive speech activities. Listening.	Basics of business correspondence letters, questionnaires. Message, announcement, table, city plan, form/questionnaire/questionnaire, instruction, private/service letter. Schedule of hours/occupations/trains.
Professional milieu of communication. Types of texts for teaching productive types of speech activity.	Appeal public/private, greeting/congratulations/wishes, request for information, private/official letter, oral/written communication of personal data, brief communication of events/intentions, book plot summary, book plot interpretation, questionnaire, description of educational/productive process.
Learning strategies for working with a proposed task. Reading literature on the specialty.	Before performing the assignment, the student must understand/clarify/confine the purpose, analyze supporting resources. While performing the assignment, the student must use supporting sources, gain new information/knowledge. After completing the assignment, the student must verify the new quality/dynamics/progress, reflect on the work process and the result.
Mastering the means of speech. Vocabulary and phraseology. Annotation. Abstracting. Professional literature	Phonetic aspect. Improvement of skills of identification and differentiation of phonetic markers of utterance necessary for understanding of sound speech. Lexical aspect. Improvement of the skills required for reading comprehension and oral/written text production. Grammatical aspect. Improvement/formation of the

	skills required to recognize in reading/listening: the most common structural types of sentences, textual logical-sounding connectors.
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**Developer:**

Art. Lecturer, Department of Foreign Languages №4 V.A. Chauzova

Head of program in EPF Odile TISSIER

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<b>Name of the discipline</b>	<b><i>Russian for Foreign Students / Русский язык как иностранный</i></b>
<b>Scope of discipline</b>	<b>6 CU (216 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
1. Сферы и ситуации общения. Бытовая сфера общения.	1. Повседневно-бытовая, учебно-образовательная, социокультурная, профессиональная лексика. Ситуации, потенциально возможные в профессиональной сфере общения.
2. Темы и проблемы общения. Учебно-познавательная сфера.	2. 1 Взаимопонимание. Общение в семье/на работе. Речевой этикет. Частная беседа. Табуированные аспекты общения в разных культурах. Многоязычие в современном мире/стране/регионе/ учебной группе. Личный опыт изучения языков. 2.2. Работа в офисе. Установление контактов с сотрудниками.
3. Социокультурная среда. Типы текстов для обучения рецептивным видам речевой деятельности. Аудирование.	3. Основы деловой переписки письма, анкеты. Сообщение, объявление, таблица, план города, формуляр/вопросник/анкета, инструкция, письмо частное/служебное. Расписание режима работы/занятий/поездов.
4. Профессиональная среда общения. Типы текстов для обучения продуктивным видам речевой деятельности.	4. Обращение публичное/частное, приветствие/поздравление/пожелание, запрос информации, письмо частное/официальное, сообщение личных данных в устной/письменной форме, краткое сообщение о событиях/намерениях, изложение сюжета книги, интерпретация сюжета книги, заполнение анкеты, описание учебного/производственного процесса.
5. Учебные стратегии при работе с предложенным заданием. Чтение литературы по специальности.	5. Перед выполнением задания студент должен понять/уточнить/конкретизировать цель, проанализировать вспомогательные ресурсы. В ходе выполнения задания студент должен использовать вспомогательные источники, получить новую информацию /знания. После выполнения задания студент должен проверить новое качество/динамику/прогресс, осуществить рефлекссию процесса работы и результата.

<p>6. Овладение речевыми средствами. Лексика и фразеология. Аннотирование. Реферирование. Профессиональная литература</p>	<p>6. Фонетический аспект. Совершенствование навыков идентификации и дифференциации фонетических маркеров высказывания, необходимых для понимания звучащей речи. Лексический аспект. Совершенствование навыков, необходимых для понимания текстов при чтении и при порождении текстов в устной/письменной форме. Грамматический аспект. Совершенствование/формирование навыков распознавания при чтении/аудировании: наиболее распространенных структурных типов предложения, текстовых логико-смысловых коннекторов.</p>
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**Developer:**

Professor of the Russian Language Department L.P. Yarkina

Associate Professor of the Russian Language Department I.Yu. Varlamova

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Специализация «Space Mission and System Design /

Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<b><i>English Language / Английский язык</i></b>
<b>Scope of discipline</b>	<b>2 CU (72 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Spheres and situations of communication. Domestic sphere of communication	Casual, educational, socio-cultural and professional vocabulary. Situations potentially possible in the professional sphere of communication
Themes and problems of communication. The educational-cognitive sphere.	Mutual understanding. Communication in the family/workplace. Speech etiquette. Private conversation. Taboo aspects of communication in different cultures. Multilingualism in the modern world/country/region/ in study group. Personal experience of language learning. Working in an office. Establishing contacts with employees.
Socio-cultural environment. Types of texts for teaching receptive speech activities. Listening.	Basics of business correspondence letters, questionnaires. Message, announcement, table, city plan, form/questionnaire/questionnaire, instruction, private/service letter. Schedule of hours/occupations/trains.
Professional milieu of communication. Types of texts for teaching productive types of speech activity.	Appeal public/private, greeting/congratulations/wishes, request for information, private/official letter, oral/written communication of personal data, brief communication of events/intentions, book plot summary, book plot interpretation, questionnaire, description of educational/productive process.
Learning strategies for working with a proposed task. Reading literature on the specialty.	Before performing the assignment, the student must understand/clarify/confine the purpose, analyze supporting resources. While performing the assignment, the student must use supporting sources, gain new information/knowledge. After completing the assignment, the student must verify the new quality/dynamics/progress, reflect on the work process and the result.
Mastering the means of speech. Vocabulary and phraseology. Annotation. Abstracting. Professional literature	Phonetic aspect. Improvement of skills of identification and differentiation of phonetic markers of utterance necessary for understanding of sound speech. Lexical aspect. Improvement of the skills required for reading comprehension and oral/written text production. Grammatical aspect. Improvement/formation of the

	skills required to recognize in reading/listening: the most common structural types of sentences, textual logical-sounding connectors.
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<b>Name of the discipline</b>	<i>Cross-Cultural Training (Professional and Cultural Visits) / Межкультурная подготовка</i>
<b>Scope of discipline</b>	<b>2 CU (72 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
The importance of cross-culture training	Working in different culture countries. Collaboration for working on one project with teams from other countries of different cultures. Working of divisions or departments of the company in different countries Suppliers from other countries for outsource activities. Customers located in different countries of different cultures. When partners and alliances with parties from diversified cultures.
The main variables of cross-culture communication	1. Time and Space 2. Fate and Personal Responsibility 3. Face and Face-Saving 4. Non-Verbal Communication
Creating Cross-Cultural Awareness	Elements of Russian and French cultures. Learning different cultural factors which affect trusts, beliefs, attitudes, perceptions and understandings in France and in Russia

**Developers:**

Senior lecturer at the Department of Foreign Languages №4 V.A. Chauzova

Senior lecturer at the Department of Foreign Languages №4 I.S. Andryushchenko

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Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>Programming (Python, C++) / Программирование (Python, C++)</i>
<b>Scope of discipline</b>	<b>2 CU (72 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Programming	Machine representation of a number. Basic mathematical operations. Computing system composition: hardware and software. The concept of machine code. Compilation and interpretation. Review of modern programming languages.
Number systems	Number recording rules. Transition between calculus systems. Horner's scheme. Number systems in Python. Arithmetic operations in an arbitrary number system.
Algebra of logic	Logical constructs in the structure of the program. Boolean variables. Algebraic operations on logical statements. Normal forms of logical expressions: conjunctive and disjunctive normal forms. The laws of the algebra of logic.
Elements of the theory of algorithms	The concept of an algorithm. Turing machine. Computability. Complexity theory. Exponentiation: Algorithm analysis (smart exponentiation). The knapsack problem. Greedy algorithm. Gradient descent method as an example of a greedy algorithm. Divide and Conquer strategy. Recursive algorithm.
Basic syntax elements of the Python language	Basic syntax of Python. Memory model and basic data types. Loops and Lists. Functions. Libraries. Scientific Python: numpy, scipy, matplotlib.
Fundamentals of programming. Python.	Sorting and Searching Algorithms Graph algorithms Dynamic programming Programming paradigms Object Oriented Programming

**Developer:**

Senior Lecturer of the Department of Mechanics and Control Processes A.S. Samokhin



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Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<b><i>Databases / Базы данных</i></b>
<b>Scope of discipline</b>	<b>2 CU (72 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Introduction to databases	Information, data, knowledge. Terminology. Automated information system. The notion of a database. Database management systems. The main components of a database management system. Three-tier architecture of a DBMS. Data models. Relational model of data. Relationship, relationship schema, relationship properties.
Operations of relational algebra	Basic relational algebra operations: projection, selection, Cartesian product, union, difference, intersection. Performing operations on relations.
Structured query language SQL	Data Definition Language (DDL). Data Manipulation Language (DML - Data Manipulation Language). Data Control Language (DCL - Data Control Language). Main SQL objects: tables, views, functions, stored procedures, triggers, cursors, indexes, etc.
Designing relational databases	Infological design. Entity-relationship method. ER data model. Logical database design. Physical database design. Relationship normalization. Denormalization of relationships.
Multi-user access to data	Transaction management. User management. Database administration. Ensuring data protection in the database.
Creating application programs that use the database	User interface of the program. Application data sources. Data manipulation. Data output to external files.

**Developer:**

Associate Professor of the Department of Mechanics and Control Processes L.V. Kruglova

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Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>Remote Sensing and Geoinformation Systems / Дистанционное зондирование и геоинформационные системы</i>
<b>Scope of discipline</b>	<b>10 CU (360 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Introduction to remote sensing. Directions for application of remote sensing data.	Meeting Lecturers and Course Introduction. Busting Myths about Satellite Images. Introduction to Earth Remote Sensing
Interaction of radiation with objects.	Physical basics of Remote Sensing
Satellites and remote sensing sensors.	Sensors and Platforms. Satellites. Band Combinations. Monitoring air quality with Sentinel-5P data. Spectral Indices. Vegetation indices, Landscape indices, Buildings indices
Geographic Information Systems	Introduction. Basic definitions and principles. GIS structure. Data integration in GIS. GIS classifications, Raster and vector, Geographical and attribute data in GIS. Buffers, filters, mutual visibility, geocoding, zoning, GIS reports. Classification, reclassification. Dissolution of boundaries, Barriers. The route of least cost. Network analysis
Characteristics of images. Preliminary processing of remote sensing data.	Imagery, Metadata and Access. Image Pre-Processing
Earth Engine Platform	Intro to Earth Engine Platform. GEE App Development App Development - Widgets and Panels. EE Basics - Histogram stretching, Cloud-free composites

**Developer:**

Senior Lecturer of the Department of Mechanics and Control Processes V.K. Lobanov

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<b>Name of the discipline</b>	<i>Aerospace Systems / Аэрокосмические системы</i>
<b>Scope of discipline</b>	<b>5 CU (180 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Introduction to Aeronautics	Introduction, vocabulary, knowledge of aircraft Models Airplane flight equations Stability, mass and balance, mission Kinematics of the helicopter rotor Aerodynamic actions Propulsion Performances Bottom of air navigation, instrumentation Innovation
Introduction to the Spatial field	Make a link between the above-mentioned theories and the structural engineer work in the frame of launcher projects
Helicopter System	General mechanics of helicopter, especially the control system of the main rotor Momentum theory (analytical method to compute the performance of a rotor in vertical flight) Power breakdown theory (TD: application to different flight conditions) Elements for the predesign of rotor Lifting line theory (TD: application to the calculation of the blade ideal twist law for hover flight) Blade flapping motion equation and rotor control Presentation of the HOST code developed by Airbus Helicopters for the computation of the aeromechanical equilibrium and the performance of helicopter Aeroelastic behavior of the rotor blade (illustrated with HOST results) CFD methods for helicopter applications New concepts of helicopters and hybrid helicopters (fast rotorcraft and eVTOL)
Satellite System	The system component of the design of a space mission

	<p>The functions of the subsystem composing a spacecraft</p> <p>The main trades and techniques involved in the design, development and qualification of a space system</p> <p>A summary case of earth observation mission using all of these</p> <p>The global optimization of a space system</p>
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**Developers:**

Head of program in RUDN Yu.N. Razoumny,

Head of program in EPF Odile TISSIER

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<b>Name of the discipline</b>	<i>Structures &amp; Materials Modelling / Моделирование конструкций и материалов</i>
<b>Scope of discipline</b>	<b>5 CU (180 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Structure Dimensioning through FEM	Abaqus, convergence study, boundary conditions, mesh, interpolation function The meaning of parameters in Abaqus according to the theory Linear static calculs in Abaqus
Structural Dynamics	Eigen modes, vibration insulation, tuned mass damper, modal superposition, projection, anti-resonance
Composite Materials	This introductory course on the mechanics of composite materials aims to provide the engineers with the basic concepts and methods necessary for design and numerical simulation of composite structures. Anisotropic elasticity The methods of scaling composites The failure criteria of composites

**Developers:**

Head of program in RUDN Yu.N. Razoumny,

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<b>Name of the discipline</b>	<i>System Design / Системное проектирование</i>
<b>Scope of discipline</b>	<b>5 CU (180 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Flight Control	Reminders and general information, Design constraints guiding the design of CDV systems Components of a CDV system "Good recipe" for building architecture. Different examples of civil aircraft. The development process and the industry
Applied servo-control	A rapid prototyping method for a corrector The key characteristics that will size the performance of a controlled system, Application of the prototyping method for a corrector to piloting a missile
Avionics	The challenges, techniques and processes associated with the maintenance of an airliner in an airline. Role of aircraft maintenance for an airline, Definition and launch of maintenance work, Carrying out maintenance work in the workshop and associated techniques.
Guidance - Navigation- Control (GNC)	The problem of a launcher's flight control, ie the following 3 functions: navigation, guidance and piloting

**Developers:**

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Head of program in EPF Odile TISSIER

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<b>Name of the discipline</b>	<b><i>On-board Energy / Бортовая энергия</i></b>
<b>Scope of discipline</b>	<b>5 CU (180 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Launcher Electrical systems	The main reliability, availability and security requirements that apply to onboard avionics on launchers and then synthesizes the different solutions offered (dedicated architectures, redundancy management, notions of Fail Operational, Fail Safe, and so on) installed on the Ariane 5 launcher, to meet these requirements. The software embedded within the Ariane 5 launcher. The development and validation phases, as well as the functional aspects
Satellite Electrical systems	Detailed presentation of the different components of the electrical architecture of a satellite (battery, solar generator, packaging and distribution module) Development of a loop for regulating a battery charge on Matlab (PID) using the different models given to students and then characterized by their care
Electrical Propulsion	Introduction to the electric propulsion of space vehicles. It should allow students to understand the interest of this propulsion mode and to familiarize themselves with the different types of systems. Comparison between chemical and electric propulsion from concrete cases. Types of electric thrusters for satellites The basic principles of the three main classes of propellants are then presented. The functioning and the performances of various thrusters and their variants: resistojets, arcjets, thrusters without neutralizer, ionic motors with grids and Hall current thrusters Design of an electric propulsion system
Launcher Propulsion	Thrust creation Classification of gas turbines Elements of thermo and aerodynamics Gas turbine cycle One-dimensional flow Turbomachines: general Axial and centrifugal compressors

	Axial turbines
Aircraft Propulsion	History of aeronautical turbomachinery. General knowledge of turbomachinery The mechanisms of propulsion Establishing a propulsive balance of a device Establishing the cycle of a turbomachine Using aerodynamic and thermodynamic relationships Sizing an axial or centrifugal compressor stage Establishing a triangle of speeds Dimensioning a turbine stage

**Developers:**

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<b>Name of the discipline</b>	<i>Dynamics and Control of Space Systems / Динамика и управление космическими системами</i>
<b>Scope of discipline</b>	<b>10 CU (360 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Methods for optimizing the orbital structures of satellite systems	<ol style="list-style-type: none"> <li>1. General principles for satellite systems design. Methods for constructing systems for global continuous observation of the Earth's regions. Ballistic design of systems for continuous zonal monitoring of the Earth's surface.</li> <li>2. Determination of the time gap in the monitoring of one frontal group of the entire surface of the Earth. Methods for constructing satellite systems for periodical observation of the Earth's surface. Construction of ballistic structures for monitoring systems of the entire surface of the Earth with small gaps in observation. Construction of systems for periodical monitoring of an area on the Earth's surface. Ballistic design of spacecraft probabilistic systems.</li> <li>3. Spacecraft communication systems. Satellite radio navigation systems. Features of the construction of meteorological satellite systems. Construction of outer space monitoring systems. Ballistic design of systems using ballistically coupled spacecraft groups.</li> <li>4. Space tether systems. Orbital functioning of the connected space objects. Rapprochement in space using tether systems. The method of forming optimal modes of tether systems controlled movement in solving practical problems.</li> </ol>
Numerical and analytical methods for optimizing orbital maneuvers	<ol style="list-style-type: none"> <li>1. Equations of spacecraft motion in deviations from motion along the circular reference orbit. Single-impulse maneuvers. Changes in the shape of the orbit as a result of the application of velocity impulse. Estimation of the magnitude of the maneuvers, the choice of the initial deviation along the orbit at the spacecraft start. Necessary optimality conditions. The main types of tasks for spacecraft optimal maneuvering.</li> <li>2. Optimal maneuvering in the space debris problem. Spacecraft avoidance maneuvers from collision with space debris. Assessment of maneuvers performed by an active space object.</li> <li>3. Optimal maneuvering in the space service problem. Planning the optimal service for a constellation of spacecraft in non-coplanar orbits. Assessment of maneuvers performed by active spacecraft when transferring to the vicinity of serviced objects.</li> </ol>

<p>Methods for calculating the disturbed motion of spacecraft in the force field of several celestial bodies</p>	<ol style="list-style-type: none"> <li>1. The two-body problem. Kepler's empirical laws. First integrals for the Kepler problem. Phase portrait. Osculating elements. Equations of indignant motion in the occupying elements.</li> <li>2. The three-body problem. The circular restricted three-body problem. Stability of libration points. The Hill's problem. The Sitnikov problem. The gravitational potential of the Earth. The Euler problem of two fixed attracting centers. Generalized problem of two fixed centers.</li> <li>3. The N-body problem. The stability of the solar system. Laplace's theorem. KAM theory. Jacques Lascard's research.</li> <li>4. The motion of a rigid body in a central gravitational field. Satellite approximation. Limited formulation for the satellite motion problem. Relative equilibria. The problem of Leonov and the stub.</li> <li>5. Influence of light pressure on the motion of a spacecraft. Solar sail.</li> </ol>
<p>Solving of practical problems</p>	<ol style="list-style-type: none"> <li>1. Lagrange problem as the problem of destroying an asteroid provided that the final energy costs of the rocket flight are minimal</li> <li>2. Autonomous Flight Control of Spacecraft</li> <li>3. Spacecraft Aerodynamic Control at Planet Landing</li> <li>4. Optimization of the shape of the spaceship in Newton's aerodynamic problem</li> <li>5. Flight trajectories determined by a system of differential equations with singular points</li> </ol>

**Developers:**

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**COURSE SYLLABUS**

**Educational program**

01.04.02 «Applied Mathematics and Computer Science /  
Прикладная математика и информатика».

Специализация «Space Mission and System Design /  
Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>Machine Learning and Big Data Mining / Машинное обучение и анализ больших данных</i>
<b>Scope of discipline</b>	<b>4 CU (144 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Introduction to the subject "Big Data Processing"	Review of problems solved by machine learning algorithms. Classification of machine learning algorithms.
Linear Regression Models.	Linear regression. Linear regression models. Basic functions. Regularization.
Logistic regression	Objective function of logistic regression. Regularization of logistic regression.
Cluster analysis.	The main types of cluster analysis tasks. Similarity measures and distance functions. Selection of the clustering criterion. Cluster methods based on the Euclidean metric. Hierarchical clustering. Method of K-within-group means. The use of graph theory methods in clustering problems. Clustering based on the analysis of probability densities.
Neural networks	The structure of the neuron. Neural network structure. Training a neural network using an error backpropagation algorithm.
Decision trees	Decision tree structure. Types of separating functions. Decision tree training. Random Forest algorithm.
Clustering	Review of existing classification algorithms. K-means algorithm

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Специализация «Space Mission and System Design /  
Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<b><i>From Data Acquisition to Data Treatment / Сбор и обработка данных</i></b>
<b>Scope of discipline</b>	<b>4 CU (144 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Introduction to Data acquisition	History. Basic terms. Sources and systems
The components of data acquisition systems	Sensors, to convert physical parameters to electrical signals. Signal conditioning circuitry, to convert sensor signals into a form that can be converted to digital values. Analog-to-digital converters, to convert conditioned sensor signals to digital values.
DAQ hardware	DAQ device drivers Input devices: 3D scanner, analog-to-digital converter, time-to-digital converter Computer Automated Measurement and Control (CAMAC) Industrial Ethernet Industrial USB LAN eXtensions for Instrumentation Network interface controller PCI eXtensions for Instrumentation VMEbus VXI
DAQ software	Specialized DAQ software may be delivered with the DAQ hardware. Software tools used for building large-scale data acquisition systems include EPICS. Other programming environments that are used to build DAQ applications include ladder logic, Visual C++, Visual Basic, LabVIEW, and MATLAB.
Data Treatment	Statistical treatment of data. Treatment of data and distribution

**Developers:**

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Прикладная математика и информатика».

Специализация «Space Mission and System Design /

Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>Applied Mechanics and Engineering / Прикладная механика и проектирование инженерных систем</i>
<b>Scope of discipline</b>	<b>6 CU (216 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Spatial Mechanics	<p>The motion of the satellites under the influence of the gravitational force, and the effects of the perturbations due to atmospheric drag, Earth oblateness.</p> <p>The three Kepler's laws and the law of conservation of energy</p> <p>Keplerian orbital elements as a function of initial conditions (position and speed) and vice versa</p> <p>Design transfer strategies between orbits (intersecting or not) and calculate maneuvers and ergol consumption</p> <p>The principal sources of orbits perturbations and explain their impact on keplerian orbital elements evolution</p> <p>Patched-conic method to plan interplanetary missions</p> <p>The different orbit and constellation types and know what mission they are dedicated to (Earth observation, telecommunication...)</p>
Flight Mechanics	<p>Introduction to flight mechanics allowing the pre-dimensioning of planes of all types, in their performance, their balancing and their stability.</p> <p>The tools presented require notions of point mechanics for the calculation of performance and solid mechanics for balancing and static stability.</p> <p>Practical elements of the dynamic system are introduced during the course which should make it possible to numerically calculate the dynamic stability of an airplane.</p> <p>Elements of general culture related to aeronautics are also provided</p>
Basic Aerodynamics	<p>The major aerodynamic phenomena related to the forces and moments exerted by a fluid on a body.</p> <p>Flow regimes from the incompressible to the supersonic.</p> <p>Analytical tools, based on modelling approximations, to quickly estimate the aerodynamic coefficients associated with aerodynamic profiles and wings</p>

Observation of practical problems	Lagrange problem as the problem of destroying an asteroid provided that the final energy costs of the rocket flight are minimal Autonomous Flight Control of Spacecraft Spacecraft Aerodynamic Control at Planet Landing Optimization of the shape of the spaceship in Newton's aerodynamic problem Flight trajectories determined by a system of differential equations with singular points
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Специализация «Space Mission and System Design /

Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<b><i>Systems Engineering / Проектирование инженерных систем</i></b>
<b>Scope of discipline</b>	<b>6 CU (216 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Management of Complex Technical Projects	<p>Introduction to the main structuring concepts of systems engineering.</p> <p>Ability to describe an engineering cycle in square root</p> <p>Ability to lead the design phase of an engineering project according to a square root cycle</p> <p>Ability to describe a system according to an operational vision: Context (context diagram - repository of stakeholder requirements), operational modes / operational scenarios / operational criteria (use case diagram, transition diagram)</p> <p>Ability to describe a system according to a functional vision (Functional tree, flowchart, repository of requirements for technical functions)</p> <p>Ability to describe a system according to an organic vision (organic tree structure, organic requirements repository, cost &amp; mass balance)</p> <p>Ability to trace function / organ allocations (traceability matrix)</p>
Applied Systems Engineering	<p>Concepts and key points used in system engineering applied to Aircraft System design, from the customer need collection down to the system architecture, with RFL model-based approach which is used more and more in system developments. Focus is also made on simulation in order to make students be aware of the simulation pros and cons.</p>
Lifecycle Analysis	<p>PLM makes it easier to work together in industrial contexts where the teams of engineers are becoming larger.</p> <p>Concretely, it is software with which the user will store and retrieve data (CAD, BOM, etc.). The concepts of configuration management (classification, roles, management of changes and transmission of information) are therefore at the heart of the concepts related to this type of tool.</p> <p>System engineering has turned to models as an interface to interact with all trades (Model Based System Engineering), in a PLM context; it allows it to find itself at the heart of product development (System-Driven Product Development).</p> <p>The concept of digital twin arises from the need to limit trial and error cycles and therefore to improve (and speed up) the design of</p>

	<p>the product, its manufacture and its maintenance. The digital twin allows simulations to be performed on representative models. Digital Continuity Lines (Digital Threads) link certain trades to each other at specific periods in the life of the product and are based on representative Digital Twins.</p> <p>The aim of this course is to present these different concepts and thus prepare the students for the industrial context in which they may have to evolve.</p>
Dependability	<p>General introduction to the concept of the SDF</p> <p>Methodology of SDF studies</p> <p>Introduction to SDF (in 3 parts with exercises: Analysis of Failure Modes, their Effects and their Criticality)</p>

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Специализация «Space Mission and System Design /  
Баллистическое проектирование космических комплексов и систем»

<b>Name of the discipline</b>	<i>Modelling and Validation / Моделирование и валидация</i>
<b>Scope of discipline</b>	<b>4 CU (144 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Statistics Engineering	From the basic analysis of a series of experimental data and its translation into statistical distribution, the course gradually becomes more complex: - comparison of two series then more than two series between them - notion of simple correlation - statistical modeling: Multiple Linear Regression - analysis of complex tables by Principal Component Analysis - search for clusters by Hierarchical Classification - study of a qualitative response by Discriminating Factor Analysis

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Баллистическое проектирование космических комплексов и систем»

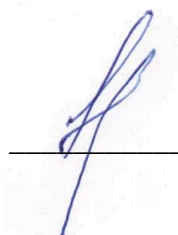
<b>Name of the discipline</b>	<i>Virtual Reality and Computer Vision / Виртуальная реальность и компьютерное зрение</i>
<b>Scope of discipline</b>	<b>4 CU (144 h.)</b>
<b>Discipline summary</b>	
<b>The name of the sections (topics) of the discipline</b>	<b>A summary of the sections (topics) of the discipline:</b>
Overview of VDR systems.	History of development of VDR systems. Application of VDR technologies.
Principles of construction of virtual and augmented reality systems.	Interaction of the user-human and model reality. Simulation of operations possible with real objects. Immersive perception of the model of reality.
Image generation in VDR systems.	Perspective projection. Orthogonal projection. Depth detection with a stereoscopic system. Affine transformations. Three-dimensional models of objects.
Generating three-dimensional models and images.	Modeling three-dimensional objects. Clipping primitives. Defining the visibility of primitives. Using textures. Lighting models. Ray tracing. Techniques and techniques for tracking user positions.
Devices for virtual and augmented reality systems.	Formation of a stereoscopic image. Technologies of augmented reality. Technologies of the mixed reality. Devices for VR and DR systems. VR in medicine. Projection on the windshield of a car. Designing printed circuit boards.
Security problems in VDR systems	. Solving security problems with AR / VR. VR technologies and security problems. Risks and dangers of VR / AR.

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