Erasmus + course on Aerospace Engineering level 2 in the fall semester 2024/2025 at the Faculty of Mechatronics, Armament, and Aerospace

Name of the course	ECTS	Semester	Cycle	Language
Aircraft Materials	2 ECTS;	Fall	Bachelor	English
Strength of Materials and Structures	3 ECTS;	Fall	Bachelor	English
Aerodynamics	3 ECTS;	Fall	Bachelor	English
Flight Mechanics	2 ECTS;	Fall	Bachelor	English
Heat Transfer	2 ECTS;	Fall	Bachelor	English
Avionic Systems	2 ECTS;	Fall	Bachelor	English
Theory of Aircraft Engines	5 ECTS;	Fall	Bachelor	English
Strength of Aircraft Structure	5 ECTS;	Fall	Bachelor	English
Hydropneumatics Systems	3 ECTS;	Fall	Bachelor	English
Propellers and Rotors	1 ECTS;	Fall	Bachelor	English
Basics of Mechanical Engineering 2	2 ECTS;	Fall	Bachelor	English

Aircraft Materials:

Requirements for aircraft construction materials. Strength, technological (formability, heat treatment, joining methods) and performance (heat resistance, corrosion resistance, fatigue life, abrasion resistance, erosion resistance, etc.) characteristics of the main groups of materials used in the construction of airframes and aircraft propulsion systems.

Strength of Materials and Structures:

Introductory information. Experimental basis for the determination of mechanical properties of materials. Calculation of tensile and compressive strength of rods. Moments of inertia of plane figures. Internal forces in rods. Bending of a straight bar. Axis of deflection of a straight bar. Statically indeterminate bending beams. Stress state theory. Strain state theory. Relationships between deformation state and stress state. Stress hypotheses. Torsion of bars. Compound action of internal forces in simple rods. General energy theorems and their application. Curved rods. Stability of rods. Fundamentals of stress analysis, free torsion of rods of any cross-section. Non-free deformation of thin-walled rods of open cross-sections. Axially symmetric thin-walled tanks. Thin plates. Elements of dynamics of elastic systems. Stress of materials under periodically varying loads. Material creep.

Aerodynamics:

Introduction to aerodynamics, aerodynamic objectives and research methods in aerodynamics. Airfoil theory: description of geometry, pressure distribution over the airfoil, aerodynamic force coefficients, airfoil aerodynamic characteristics. Finite extension airfoil: description of geometry, rotary lifting line theory, induced drag, airfoil aerodynamic characteristics. Subcritical and supercritical airfoil and wing flow. Elements of high speed aerodynamic theory: small disturbance theory,

sound barrier, densification and dilution waves, aerodynamic heating. Aerodynamic interference, supersonic air flow, elements of complete aircraft aerodynamics, experimental aerodynamic characteristics of model aircraft.

Flight Mechanics

Flight mechanics objectives, forces acting on the aircraft. Dynamics of aircraft motion as a material point. Motion of aircraft on rectilinear trajectories inclined at any angle. Aircraft transient motions on rectilinear and curvilinear tracks in the vertical and horizontal plane and on space tracks. Issues of aircraft take-off and landing, aerodynamic characteristics in take-off and landing configurations. Dynamics of aircraft motion as a material solid. Aircraft equilibrium, static stability and longitudinal controllability. Equilibrium, static stability and lateral controllability, aircraft equilibrium curve. Moments acting on an aircraft in transient motion. Peculiarities of aircraft flight at large angles of attack. Suborbital and orbital flights of spacecraft.

Heat Transfer

Concepts and quantities of description of heat transfer issues. Fourier, Newton and Stefan-Boltzmann Laws. Calculation of steady-state heat transfer through multi-layered flat and cylindrical walls using thermal resistance. Calculation of heat transfer through rods and ribs under various boundary conditions. Determination of heat transfer coefficients for fluid flows inside and outside channels. Determination of heat transfer coefficients for flowing flat walls. Cooling of gas turbine blades. Heat transfer boundary conditions for gas turbine blades. Determination of temperature distribution in a model turbine blade using Excel.

Avionic Systems

Definition, architectures and basic characteristics of avionics systems. Electrical power sources on aircraft. Lighting and light signalling systems. Rain and ice protection systems. Aircraft engine ignition systems. Organisation elements of aircraft on-board computer and data exchange systems. Fibre optics and fibre optics technology. Integrated modular avionics systems. On-board information and maintenance imaging systems. Flight data and cabin voice recorders. Cabin and information systems. Construction and principles of aeronautical measuring instruments and systems. Autonomous Navigation Systems. Aircraft Control Systems. Electromagnetic compatibility issues. Flight and traffic management systems. Servomechanisms and actuators. Fundamentals of radio wave propagation. Radio-electronic communication equipment. Non-autonomous navigation systems. Systems and devices aiding the instrumented landing process. Secondary radar in air traffic control, collision avoidance systems. Radio altimeters and ground proximity warning devices. Weather radars, Doppler radars, area navigation systems.

Theory of Aircraft Engines:

Operating principles of an aircraft piston engine and their characteristics. Operating parameters of a single-flow turbine jet engine. Two-flow turbine jet engine and its application. Propeller and helicopter turbine engine. Parameters and operating characteristics of components (inlet, compressor, combustion chamber, turbine and types of exhaust systems in turbine engines). Basic characteristics of turbine engines. Analysis of engine characteristics linking engine parameters to flight parameters. Conclusions resulting from the analysis of fundamental importance to the problems of construction and operation of aircraft engines.

Strength of Aircraft Structures:

General information. Girders. Membrane theory of cylindrical shells. Free torsion of thin-walled prismatic bars. Open section bending and shearing of thin-walled bars. Bending and shear of thin-walled bars with closed cross-section. Sandwich construction (three layer construction). Elastic stability of bars. Elastic stability of plates. Structural work after loss of stability. Current directions of development of strength calculation methods for aeronautical structures.

Hydropneumatic Systems:

Working fluids and gases used in hydropneumatic systems and conditions of their use. Hydropneumatic energy sources used on-board of aircraft. Hydraulic and pneumatic actuators. Hydraulic boosters. Control elements for flow direction, pressure and flow rate of liquids and working gases. Rigid and flexible hoses. Couplings and connections. Filters. Reservoirs and

dampers. Fuel systems. Fire suppression systems. Air-conditioning systems. Anti-icing systems. Hydraulic systems. Oil systems and cooling. Aircraft crew oxygen systems and emergency equipment. Principles of operation of on-board hydropneumatic equipment.

Propellers and Rotors:

General information. Aerodynes, rotorcraft, propellers, helicopters.
Lift rotors, rotor hubs, joints and blades of lift rotors. Propellers. Geometric and aerodynamic quantities characterising a propeller. Vortex theory as applied to propellers and carrier rotors. Flux theory of propeller and carrier rotor. Thrust, efficiency. Coefficients characterising propeller performance. Simplified vortex theory of propellers and mainspring rotors. Apical loss coefficients. Model of vortex carrier line. Blade element theory as applied to propellers and carrier rotors. Elements of non-stationary aerodynamics. Peculiarities of carrier rotor aerodynamics. Working ranges of the carrier rotor. Profile power. Elements of helicopter flight mechanics. Forces on control levers. Basic characteristics of controllability. Steady states of flight. Propeller blade strength

Basics of Mechanical Engineering 2:

Characteristics, classification and applications and design of sliding and rolling bearings. Bearing materials. Calculation and principles of bearing selection. Probability of damage on the example of rolling bearings. Mechanisms, types and applications. Methods of analysing kinematics and dynamics of mechanisms. Kinematic analysis of plane and spatial mechanisms. Mechanism synthesis. Basic principles of modelling in the environment of computer-aided design, construction and drafting (CAD). Basic knowledge of databases. Geometric analysis of machine part models. Geometric analysis of machine part models. Concurrent and conceptual design. Collaborative design using CAD systems. Visualisation and simulation of product operation in CAD systems.