RTU Course "Helicopter Aerodynamics"

15E03 Lidaparātu teorijas un konstrukcijas katedra

General data

Code	TAS105
Course title	Helicopter Aerodynamics
Course status in the programme	Compulsory/Courses of Limited Choice; Courses of Free Choice
Course level	Undergraduate Studies
Course type	Professional
Field of study	Mechanics, Mechanical Engineering, Machine Building
Responsible instructor	Pavelko Vitālijs
Academic staff	Pavelko Igors
Volume of the course: parts and credits points	1 part, 2.0 Credit Points, 3.0 ECTS credits
Language of instruction	LV, EN, RU
Possibility of distance learning	Not planned
Abstract	Aerodynamics of aviation airfoil: drag, lift forces and moments. Geometrical and aerodynamically characteristics of airfoils. Center of pressure and aerodynamic center. Calculation methods of airfoils. Influence of geometrical characteristic of blade on it's aerodynamically characteristics. Helicopter main rotor aerodynamics. Effects of gyroscopic precession. Torque reaction and yaw control. Dissymmetry of lift. Blade tip stall. Coriolis effect and compensation. Vortex circle state, power settling, overpitching. Autorotation. Ground effect. Cyclic control. Collective control. Yaw control: anti-torque control, tail rotor, bleed air. A main rotor head: design and operation features. Blade damper function. Rotor blades: blades of main and tail rotors. Trim control, fixed and adjustable stabilizers. Artificial loads. Balancing and rigging.
Goals and objectives of the course in terms of competences and skills	Acquire theoretical knowledge of helicopter aerodynamics principal regularities and research methods. Understand the approaches of helicopter aerodynamic analysis. Get acquainted with the experimental techniques in aerodynamics.
Structure and tasks of independent studies	Preparation of reports of laboratory works: • experimental determination of airfoil lift coefficient (1 h); • experimental determination of aerodynamic characteristics of the air prop (1h). Preparation of reports of calculation-graphic works: • analysis of airfoil in the ideal incompressible two-dimensional parallel flow (2 h); • helicopter aerodynamic performance(2 h). Working with the literature (10 h).
Recommended literature	1. V.Pavelko. Gaisakuģu aerodinamika // Mācību līdzeklis.- Rīga: RTU, 2009.- 258 lpp. 2. I. Pavelko, V. Pavelko. Metodiskie norādījumi laboratorijas un aprēķinu-grafiskajiem darbiem „Aerohidromehānika”. – Rīga, RTU Izdevniecība, 2006 – 31 lpp. 3. Aerodynamics, Aeronautics, and Flight Mechanics, 2/e Barnes W. McCormick// John Wiley & Sons, Inc., 1995 ISBN 0-471-57506-2 672 pages 4. Anderson, J.D. 1991. Fundamentals of Aerodynamics, 2nd ed. McGraw-Hill, New 5. JAR CPL Course: 08000 - Principles of Flight, 08100- Subsonic Aerodynamics. 1998. 250p. 6. Helicopter Aerodynamics: A&P Technician General Textbook. Chapter 2. Section F.- US Department of Transportation. FAA. 2001, 584 pp. 7. Lešinskis A. Aerodinamika, Mācību līdzeklis. Rīga: RAU, 1997. 120 lpp. 8. Mhitarjans A. M. un citi. Aerohidromehānika. - Maskava: Mašīnbūve, 1990.- 352 lpp. 9. Airframe and Powerplant Mechanics. Airframe Handbook. US Department of Transportation. Federal Aviation Administration. New Delhi: Himalayan Books.1994, 630p.
Course prerequisites	Mathematics, physics, mechanics. Fundamentals of Aerodynamics, CAD. MATLAB, EXCEL.

Course outline

Theme	Hours
Airfoil and wing geometrical characteristics. Zhukovskii theorem. Kutta postulate.	2
Application of a potential flow theory to profile lift determine. Thin airfoil theory.	2
Vortex theory of the wing of finite span. General equations of vortex theory. Lift line theory of Prandtl.	2
Downward deflection of airflow and induced drag. Adverse drag. Aerodynamic coefficients of a blade.	2
The pressure center and focus. Pressure coefficient and its correlation to aerodynamic coefficients.	1
Aerodynamic parameters versus angle of attack, geometric parameters and Reynolds number.	1
Analysis of airfoil in the ideal incompressible two-dimensional parallel flow.	2
Experimental determination of airfoil lift coefficient.	2
Influence of compressibility on the airfoil characteristics. Regularities of compressible subsonic flow.	2
Airfoil and wing in the transonic and supersonic flow. Wave drag.	2
Geometric, kinematical and aerodynamic characteristics of the air prop.	2
Experimental determination of aerodynamic characteristics of the air prop.	2
Aerodynamic forces of the helicopter main rotor	2
Effects of gyroscopic precession. Torque reaction and yaw control.	2
Dissymmetry of lift. Blade tip stall. Coriolis effect and compensation	1

Vortex circle state, power settling, overpitching.	1
Autorotation. Ground effect.	2
Cyclic control. Collective control.	2

Learning outcomes and assessment

Learning outcomes	Assessment methods
Able to use analytical methods of aerodynamics to determine aerodynamic characteristics of the airfoil.	Calculation-graphic work: Analysis of airfoil in the ideal incompressible two-dimensional parallel flow.
Able to orientate in the methods of experimental aerodynamics used in the experiment and the results obtained in the wing aerodynamic characteristics of the airfoil.	Laboratory work: Experimental determination of airfoil lift coefficient
Able to calculate the aerodynamic forces of helicopter main rotor.	Calculation-graphic work: The aerodynamic forces of helicopter main rotor
Able to make the optimal choice of operating mode of the airprop on the basis of the results of aerodynamic experiment.	Laboratory work: Experimental determination of aerodynamic characteristics of the airprop.
Able to deal with aerodynamics standard tasks. Able to show theoretical knowledge of main regularities and research methods of aerodynamics.	Exam.

Study subject structure

Part	CP	ECTS	Hours per Week			Tests			Tests (free choice)		
			Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.	2.0	3.0	1.0	0.5	0.5		*				