COURSE DESCRIPTION CARD - SYLLABUS

Course name
Intergrated aircraft engine design system 2 [S1Lot2-SLiPL>ZSPSL2]

Course

Field of study
Aviation

Year/Semester
4/7

Area of study (specialization)
Aircraft Engines and Airframes

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

The student should have basic knowledge and skills in mathematics, especially in the field of multivariable calculus, vector calculus and linear algebra, as well as thermodynamics, fluid mechanics and aerodynamics, as well as knowledge of the theory of aircraft engines, and also have basic knowledge and skills in the subject of Integrated Systems for Designing Aircraft Engines - semester 1.

Course objective

- Teach principles: Extend knowledge and skills from the previous semester with knowledge of approaches to modeling turbulence and chemical reactions in flow. Teach strategies for dealing with computational cases that do not allow obtaining numerical results without using multi-step procedures characteristic of these flow classes, teach interpretation of numerical results with particular emphasis on distinguishing between physical effects, physical model effects and numerical effects.

Course-related learning outcomes

Knowledge:
1. has extended and deepened knowledge of mathematics covering algebra, analysis, theory of differential equations, probability, analytical geometry as well as physics covering the basics of classical mechanics,

optics, electricity and magnetism, solid state physics, thermodynamics, useful for formulating and solving complex technical tasks related to aeronautical engineering and modeling
2. has structured, theoretically based general knowledge in the field of technology and various means of air transport, about the life cycle of means of transport, both hardware and software, and in particular about the key processes occurring in them 3. Has structured, theoretically based knowledge in the field of applied mathematics allowing for the selection of discretization schemes and numerical methods used for the analyzed problem. 3. has knowledge of the method of presenting research results in tabular and graph form, performing measurement uncertainty analysis
4. has basic knowledge of research methods and the method of preparing and conducting scientific research, and also knows the principles of editing a scientific paper
5. has basic knowledge of metallic, non-metallic and composite materials used in machine construction, and in particular their structure, properties, methods of production, heat and thermochemical treatment and the influence of plastic processing on their strength, as well as fuels, lubricants, technical gases, refrigerants, etc.
6. has basic knowledge of environmental protection in transport, is aware of the threats related to environmental protection and understands the specific impact of mainly air transport on the environment and the social, economic, legal and other non-technical conditions of engineering activities
7. has the ability to self-educate using modern teaching tools, such as remote lectures, Internet sites and databases, teaching programs, e-books

Skills:
1. is able to obtain information from various sources, including literature and databases, both in Polish and English, integrate it properly, interpret and critically evaluate it, draw conclusions, and comprehensively justify the opinions formulated by him/her
2. is able to use information and communication techniques appropriately, which are applied at various stages of the implementation of aviation projects3. is able to conduct computer simulations of flow phenomena related to the operation of aircraft propulsion components and interpret their results and draw conclusions. 3. is able to properly plan and perform experiments, including measurements and computer simulations, interpret the obtained results, and correctly draw conclusions from them
4. is able to formulate and solve tasks related to civil aviation, apply appropriately selected methods, including analytical, simulation or experimental methods
5. is able to properly select materials for simple aircraft structures, indicate differences between fuels used in aviation
6. is able to communicate using various techniques in a professional environment and other environments using a formal construction record, technical drawing, concepts and definitions of the scope of the studied field of study
7. is able to design elements of means of transport using data on environmental protection
8. the student is able to use theoretical probability distributions. The student is able to analyze and interpret statistical data. The student is able to use methods and tools of mathematical statistics in engineering practice
9. is able to use the language of mathematics (differential and integral calculus) to describe simple engineering problems. 10. the student is able to perform a comprehensive assessment of the ecological parameters of the aircraft's power unit based on the values of emission indicators of harmful gaseous compounds and particulate matter
11. is able to prepare a short scientific paper, observing basic editorial principles. Is able to select appropriate methods for the research carried out and is able to conduct a basic analysis of the results. 12. is able to organize, cooperate and work in a group, assuming different roles in it and is able to appropriately define priorities for the implementation of a task specified by himself or others
13. is able to plan and implement the process of his own permanent learning and knows the possibilities of further education (2nd and 3rd degree studies, postgraduate studies, courses and exams conducted by universities, companies and professional organizations)

Social competences:

1. understands that in technology knowledge and skills become outdated very quickly
2. is aware of the importance of knowledge in solving engineering problems and knows examples and understands the causes of malfunctioning engineering projects that led to serious financial, social or economic losses

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture (final grade consists of three components):
1. Complete group project (analytical calculations, geometry project, CFD analysis) (65%)
2. Grade from a small individual project (35%)
The project in the second semester of the subject (7th semester of studies) should, to the extent possible, be related
to the subject of the student's engineering thesis and be a project with a much higher level of detail than the project carried out in the previous semester. It may be an extension
of the project from the previous semester.
To pass the subject, it is required to obtain no less than 60% of the component points.
The grading curve for the 60%-100% range is established individually in each semester.

Programme content

Lecture semester II:
Fundamentals of RANS methodology; turbulence modeling (hypotheses, models, constraints); Discretization schemes of equations; introduction to the topology of structured meshes; differences between calculations
on different types of meshes; Range of available methodologies for turbulence modeling (DNS - LES - DES - RANS);
Laboratory semester II:
Creating 2- and 3-dimensional structured meshes with complex topologies; Strategies for obtaining stationary solutions for transonic flows and flows with limited stability;
use of numerical analysis results to create surrogate models of flow characteristics and their implementation for selected applications. Implementation of non-standard material models, including the UDRGM (user defined real gas model) model in the Ansys Fluent environment; PART - 66 (PRACTICE - 11.25 hrs.)
MODULE 16. PISTON ENGINE
16.7 Supercharging/turbocharging
System terminology;
Control systems;
Protection system. [2]

Course topics

1. RANS methodology and turbulence modeling
Basics of the Reynolds-Averaged Navier-Stokes (RANS) methodology
Hypotheses and turbulence models
Limitations of RANS methods and comparison with other approaches
2. Discretization of equations and the influence of the computational grid
Transport equation discretization schemes
Structured and unstructured computational grids
Differences in calculations on different types of grids
3. Overview of turbulence modeling methodologies
Direct Numerical Simulation (DNS) full simulation
LES (Large Eddy Simulation) and DES (Detached Eddy Simulation) models
Comparison of RANS, LES, DES and DNS: scopes of application and limitations
4. Multiphysics and multiphase modeling
The concept of multiphysics in CFD analyses
Limitations of multiphysics models on the example of commercial software
Multiphase models and their application in engineering
5. Coupled Heat Transfer Analysis and Chemical Reaction Modeling
Conjugate Heat Transfer Between Solid and Fluid

Models of Chemical Reactions in Flows
Levels of Simplification in Chemical Reaction Modeling and Their Applications
6. Practical Aspects of Numerical Analysis in Fluid Dynamics
Creating 2D and 3D Structured Meshes with Complex Topologies
Strategies for Obtaining Solutions for Transonic and Unsteady Flows
Building Surrogate Models Based on Numerical Analysis Results
7. Supercharging and Turbocharging in Piston Engines
System Terminology Related to Supercharging
Boost Control and Regulation Systems
Protection Systems and Their Role in Piston Engine Operation

Teaching methods

1. Blackboard lecture
2. Laboratory in the computer room
3. Computational projects performed using publicly available programming tools

Bibliography

Basic:
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Additional:
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Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	50	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00