Warsaw University of Technology

Faculty of Power and Aeronautical Engineering

CATALOGUE OF COURSES

Graduate studies (M.Sc. degree)
Tok 2016

Warsaw 2018

FIELDS OF STUDIES AND SPECIALIZATIONS

The graduate studies last 3 semesters and conclude with the Master of Science degree. They are offered in two specializations. Please see the table below:

Field of Studies	*Specialization*
Aerospace Engineering	Aerospace Engineering
Power Engineering	Power Engineering
	Nuclear Power engineering

The program of M.Sc. studies is the same for all specializations during the first two semesters. The studies within a particular specialization can be launched when a sufficient number of students have been admitted by the Dean of the Faculty.

Heads of specializations:

- Aerospace Engineering – prof. Cezary Galiński
- Power Engineering – prof. Tadeusz Skoczkowski
- Nuclear Power Engineering – dr Nikołaj Uzunow

Regulations of Studies

Students must comply with the „Regulations of Studies of Warsaw University of Technology" accepted by the University Senate. Please see the following sections for more details.

Dean of the Faculty decides in matters not specified by the Regulations.

Course of studies

From the second semester students must design an individual study plan for next semesters, which includes the obligatory courses, especially the specialization courses that must be repeated, and possibly the courses included in the program for higher semesters of studies.

When designing the individual study plan for the next semester, students must decide on:

- Electives - if included in the programme. There is no separate list of electives. An elective can be any course which is not included in the programme of other fields of studies given in English. Dean of the Faculty approves optional electives, e.g. lectured by the Visiting Professors.

- Division and subject of intermediate projects.
- Division and scope of diploma seminar. The seminar provides knowledge and skills required in diploma project preparation.
- Division and subject of diploma project. The division is the same as in case of diploma seminar.

Students can also select from a range of foreign language or physical education courses.

Individual study plan for the next semester must be prepared according to the prerequisites given in the catalogue, i.e. courses which must be completed before the beginning of the current course.

After each semester, the student performance is assessed and the registration procedure for the next semester is performed. At the end of the study program all the requirements for graduation must be fulfilled.

Registration procedures for each semester

ECTS Credit System

During each course a certain number of ECTS points are earned in accordance with the course significance, difficulty and the student workload required. The total number of credit points that can be earned for all courses in each semester is 30.

Evaluation System

1. At the end of each semester, students obtain one final grade for each course (regardless of the course division into lectures, tutorials and laboratory work).
2. The grading scale starts with a failing grade 2 and consists of five passing grades: 3, $3^{1/2}$, 4, $4^{1/2}$, 5.
3. In exceptional cases, students may obtain "condition" *N* final grade, which means that the student performance during the semester is evaluated positively, but the student is not allowed to take the final exam (due to valid reasons). The lecturer defines the procedures in case of "condition" *N*. This grade obliges the student to complete the course by the end of the following semester the latest, so that he does not need to repeat it and pay extra fee. If the student fails to complete the course during the following semester, the course must be repeated. Consequently, the student is obliged to cover the costs of the course repetition according to University Regulations. There are no credit points for "condition" *N*.

Requirements for registration for each semester

1. In order to register for the next semester, students are required to have a sufficient number of credit points as given in the table below.

M. Sc. Programme			
Registration for semester	II	III	IV*)
Number of collected credits	22	50	80

*) Applies to 4 semester studies

2. Students who fail to collect the required number of points are removed from the study programme, with the exception of the last two semesters of studies, for which the student can re-register.
3. Students must repeat the failed course during the next available semester. Courses can be repeated twice. Students who fail to complete the course three times will be removed from the Faculty. Students are obliged to cover the costs of course repetition according to University Regulations.
4. Dean can approve student sick leave or leave of absence. First year students may obtain sick leave only.
5. In some cases, the Dean can grant a student who is on the leave, the right to take certain courses "in advance".
6. Duration of graduate studies must not be longer than five semesters. In case the student is granted the leave, duration of studies is prolonged accordingly.
7. Surplus credit points accumulated during B.Sc. studies are not transferred to M.Sc. studies. The M.Sc. studies always begin with zero credit points.

Requirements for graduation

Requirements for graduating with the M.Sc. degree are as follows:

- Completion of all courses in the M.Sc. study program,
- For Aerospace Engineering 4-week internship in industry (recommended)
- Collecting 90 ECTS points including the preparation of M.Sc. thesis
- Writing M.Sc. thesis and passing the final exam.

The final grade for the completed study program is an average of grades received for each course. Failing grades are not included in the average.

$$Average\ grade = \frac{\sum_{i \in Z} g_i \cdot O_i}{\sum_{i \in Z} g_i}$$

Z – number of completed courses,

g_i – number of ECTS points allocated to the course,

O_i – grade for the course.

Final examinations are held four times a year – in January, March, June and October.

Brief study schedule

Brief study schedule includes information on the course title and the number of hours per semester and week. Information about a course division into lectures, tutorials, laboratory work and projects as well as the number of credit points can be found in a table for each semester.

Complete information about courses can be found in the last part of the catalogue on courses contents.

LEGEND for the list of courses (following pages)

In the following section the list of courses is given, divided into suggested sequence during standard semesters of study.

In each semester the standard set of courses gives 30 ECTS points. In the case the required (named and specified) courses do not fill standard 30 ECTS points – then ELECTIVE courses should be taken in the amount summing the semester load to 30 ECTS. Compare remarks on elective courses in the section "Course of Studies".

In the headers of tables the following abbreviations/acronyms are used:

Lc – Lecture

T – Tutorial

Lb – Laboratory

P – Project

S – Seminar

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Field of Study Lotnictwo i Kosmonautyka

Aerospace engineering	Semester 1
	Semester 2
	Semester 3

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Field of Study Lotnictwo i Kosmonautyka
Field of Specialization Aerospace engineering
Semester 1

List of specialization courses:

No.	Course number	Course name	Lc	T	Lb	P	S	ECTS points
1.	ML.ANK323A	Advanced Computational Fluid Dynamics	1	0	2	0	0	3
2.	ML.ANS646	Aircraft Systems Laboratory	0	0	3	0	0	3
3.	ML.ANS520	Composite Materials in Aerospace	2	0	0	0	0	3
4.	ML.ANK389	Control in Aerospace	2	0	0	0	0	3
5.	ML.ANK312	Dynamics of Flight	2	0	0	0	0	3
6.	ML.ANK425	Heat Transfer in Aerospace	3	0	0	0	0	4
7.	ML.ANS642	Mechanics of Thin-Walled Structures	1	1	1	0	0	3
8.	ML.ANK481A	Partial Differential Equations	2	1	0	0	0	4
9.	ML.ANK321A	Physics of the Atmosphere	1	0	0	0	0	2
10.	ML.ANK398	Space Technologies	2	0	0	0	0	2

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Field of Study Lotnictwo i Kosmonautyka
Field of Specialization Aerospace engineering
Semester 2

List of specialization courses:

No.	Course number	Course name	Lc	T	Lb	P	S	ECTS points
1.	ML.ANS600	Advanced Aero Engines Laboratory	0	0	2	0	0	2
2.	ML.ANK496	Aircraft Maintenance Management	0	1	0	0	0	2
3.	ML.ANS647	Attitude and Navigation Systems	1	1	0	1	0	4
4.	ML.ANS652	Fatigue and Aircraft Diagnostic Systems	2	0	1	0	0	4
5.	ML.ANK491	Intermediate Masters Project	0	0	0	6	0	6
6.	ML.ANK480	Physics 2	2	0	0	0	0	2
7.	ML.ANS511A	Sensors and Measurements Systems	1	0	1	0	0	3
8.	ML.ANK495	Signals and Identification Methods	1	1	0	0	0	3
9.	ML.ANS650	Structural Analysis of Aero Engines	2	0	0	0	0	4

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Field of Study Lotnictwo i Kosmonautyka
Field of Specialization Aerospace engineering
Semester 3

List of specialization courses:

No.	Course number	Course name	Lc	T	Lb	P	S	ECTS points
1.	ML.ANW138	Master Diploma Seminar	0	0	0	2	0	2
2.	ML.ANW137	Master Diploma Thesis	0	0	0	15	0	20
3.	ML.ANK306	Optimization in Aircraft Design	2	0	1	0	0	3

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Sylabus

Course name:	**Advanced Aero Engines Laboratory**
Course name in other language:	
Short name:	**AEL**
Course number:	**ML.ANS600**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Marian Gieras**

ECTS:	**2**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Advanced**	weekly:	[0,	0,	**2,**	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[0,	0,	**30,**	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

Types of aircraft engines - spark-ignition engines, diesel engines, turbine engines, ram jet engines, pulse jet engines and detonation engines. Combustion processes in aircraft engines. Methods of visualization and diagnostics of combustion processes. Experience on research stands, testing equipment, data acquisition systems, methods of flame stabilization. Emissions-control technology. Engine-speed and other performance. Getting into the bases of design of the main engine components.

Bibliography:

1. Archer R.D., Saarlas M.: “An Introduction to Aerospace Propulsion”, Prentice Hall 1996
2. Mattingly J.D.: “Elements of Gas Turbine Propulsion”, McGraw Hill 1996
3. Mattingly J.D., Heiser W.H., Pratt D.T.: “Aircraft Engine Design”, AIAA 2002
4. Strehlow R. A. “Combustion Fundamentals”, McGraw-Hill, New York 1984.
5. A. H. Lefebvre, „Gas Turbine Combustion”, Taylor & Francis, USA, 1998

Course results:

Knowledge of bases of thermodynamics, hydromechanics, gas dynamics and combustion. Knowledge of organization of combustion processes in combustion chamber of different aircraft engines. Practical skills of carried out investigation of piston and turbine engines performance characteristics.

Grading criteria:

Assessment will be made on the basis reports realised by students and the short colloquium test at the end of laboratory.

Detailed contents:

1. Types of flames and burners
2. Methods of flames stabilization in flow
3. Methods of flame visualization in research of combustion processes
4. Computer tomography of flames

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5. Detonation and deflagration
6. Investigation of pulsed engine
7. Determining of piston engine performances
8. Homogeneous charge compression ignition (HCCI)
8. Determining of turbine engine performances
9. Pulse rotational detonation engine (RDE)
10. Summary

Additional remarks (by course staff):

As the subject is of interdisciplinary character and is not based on a particular text book, students participation in lectures and exercises is highly recommended.

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Sylabus

Course name:	**Advanced Computational Fluid Dynamics**
Course name in other language:	
Short name:	**ACFD**
Course number:	**ML.ANK323A**
Course language:	**English**
Responsible for the course:	**prof. dr hab. inż. Jacek Rokicki**

ECTS:	**3**	Number of hours:	[Lc, T, Lb, P, S,]
:		weekly:	[**1,** 0, **2,** 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[**15,** 0, **30,** 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

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Sylabus

Course name:	**Aircraft Maintenance Management**
Course name in other language:	
Short name:	**AMM**
Course number:	**ML.ANK496**
Course language:	**English**
Responsible for the course:	**dr inż. Kamila Kustroń**

ECTS:	**2**	Number of hours:	[Lc, T, Lb, P, S,]
Course level:	**Intermediate**	weekly:	[0, **1,** 0, 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[0, **15,** 0, 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

Knowledge about design and maintenance philosophies and their correlations to choose an optimal maintenance strategy. Maintenance management process for novel aircraft. Problems of aging aircraft. Knowledge of random phenomena influences the maintenance system.

Bibliography:

Documentation on http://www.meil.pw.edu.pl/zsis/ZSiS/Dydaktyka/Prowadzone-przedmioty/AMM
Further Readings:
- handouts

Course results:

After completing this course the students will have skills to improve maintenance from safety and cost-effectiveness points of view

Grading criteria:

100% assessment based on one project (in presentation form)
Practical work:
yes

Detailed contents:

Background of exploitation problems including operation and maintenance systems. Knowledge of historic and present aviation organizations, regulations and skills/tools of maintenance connecting with design process. Design and maintenance philosophies and correlations. Consideration of random phenomena as stochastic processes, random variables and events. Reliability and maintenance characterization. MSG 3 and Reliability Centered Maintenance – RCM methods in maintenance optimization. Authority regulations. International Civil Aviation Organization – ICAO, IATA, Polish Civil Aviation Authority - ULC, Federal Aviation Administration - FAA, Joint Aviation Administration - JAA, European Aviation Safety Agency - EASA, Certificate of Release to Service (CRS), CAMO,

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ATA, Standards And Recommended Practices – SARP, Joint Aviation Regulations - JAR, Certification Stardaryzations -CS, Part M, Part 145, Part 147, Part 66, Part-21. Maintenance task compiling. Maintenance Program – MP, Airworthiness Directives – AD, Service Bulletin, Type Certificate – TC, Supplementary Type Certificate – STC, Continuing Airworthiness Management Exposition (CAME), Maintenance Organization Exposition (MOE), Maintenance Training Organization Exposition (MTOE), Life Limited Components– LLC, Corrosion Protection and Corrosion Prevention – CPCP, Master Minimum Equipment List (MMEL) Minimum Equipment List (MEL). Artificial intelligence. Non-Destructive Test (NDT) and Health Monitoring methods in diagnostics of novel aircraft.

Additional remarks (by course staff):

http://www.meil.pw.edu.pl/add/ADD/Teaching/Subjects/Aircraft-Maintenance-Management

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Sylabus

Course name:	**Aircraft Systems Laboratory**
Course name in other language:	
Short name:	**ASL**
Course number:	**ML.ANS646**
Course language:	**English**
Responsible for the course:	**dr inż. Przemysław Bibik**

ECTS:	**3**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[0,	0,	**3,**	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[0,	0,	**45,**	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Contents - short:

Obtain hands-on experience with principles of operation of selected aeronautical systems

Bibliography:

• instructions to laboratory experiments provided by lecturer, with recommended text for self-studying.
• user manuals of selected aeronautical system

Further Readings:

• may be provided by lecturer

Course results:

After completing the course students will have detailed knowledge about selected sensors and aircraft system components and basic laboratory measurement skills.

Grading criteria:

assessment of reports from laboratory activities

Detailed contents:

Introduction to data acquisition and handling in Matlab. Experimental testing of selected sensors and systems (magnetic, inertial navigation systems, electrical and pneumatic actuators, Global Positioning System, visual navigation systems). The details of the experimental laboratory work will be given at the first meeting in semester, according to equipment availability.

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Sylabus

Course name:	**Attitude and Navigation Systems**
Course name in other language:	
Short name:	**ANS**
Course number:	**ML.ANS647**
Course language:	**English**
Responsible for the course:	**prof. dr hab. inż. Janusz Narkiewicz**

ECTS:	**4**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[**1,**	**1,**	0,	**1,**	0,]
Form of grading:	**Continous assesment**	by semester:	[**15,**	**15,**	0,	**15,**	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

Systems for position and attitude determination used in aerospace and other fields of technology.

Bibliography:

1) Grewal M.S., Weill L.R., Andrews A.P., "Global Positioning Systems, Inertial Navigation and Integration", John Willey & Sons, 2000.
2) Lawrence A., “Modern Inertial Technology. Navigation, Guidance, and Control”. Springer-Verlag, 1998
3) Rogers R.M., "Applied Mathematics in Integrated Navigation Systems", AIAA Series, 2000.
web site materials

Course results:

Understanding principles of operation and design of navigation system for various moving platforms.

Grading criteria:

Control tests and project. Mark based on: the test results - 70%, project - 30%. Both parts should be completed.

Detailed contents:

Lecture: Overview of the methods for position and attitude determination. Earth shape and systems of coordinates. Earth gravity and gravity sensors. Architecture of the attitude systems. Linear sensor errors. Accelerometers. Gyroscpes: mechanical, vibrating, dynamically tunned, laser and FOG. INS design, leveling and gyrocompassing. Application of GNSS for attitude determination. INS/GPS integration.
Tutorials: Examples for illustrating topic presented during lectures.
Project: Design and implement algorithm for navigation and attitude data processing. Simulation program for selected navigation system in Matlab / Simulink environment.

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Sylabus

Course name:	**Composite Materials in Aerospace**
Course name in other language:	
Short name:	**CMA**
Course number:	**ML.ANS520**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Piotr Czarnocki**

ECTS:	**3**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[**2,**	0,	0,	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**30,**	0,	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Contents - short:

Typical manufacturing processes applied for parts of composite airframe. Typical designs of composite airframe parts. Fundamentals of stress analysis. Manufacturing flaws and service damage.

Bibliography:

1. Flake Campbell Jr, “Manufacturing Processes for Advanced Composites”
2. R. M. Jones, “Mechanics of Composite Materials”
3. J. J. Morena, “Advanced Composite Mold Making”

Course results:

Efekty kształcenia:
Umiejętność, w podstawowym zakresie, projektowanie lotniczych wyrobów kompozytowych, projektowania oprzyrządowania produkcyjnego do ich wykonania. Znajomość technik wytwarzania i łączenia stosowanych w produkcji kompozytowych elementów płatowca. Umiejętność przeprowadzenia podstawowej analizy wytrzymałościowej struktury kompozytowej.
Basic knowledge concerning design of composite airframe parts, design of manufacturing processes and tooling. Basic knowledge about, joining methods applicable for composite structures. Ability to carry out basic stress analysis of composite airframe parts.

Grading criteria:

average mark of two tests

Detailed contents:

Components of polymeric composite materials: reinforcement, forms of reinforcements, matrix materials, thermosets versus thermoplasts. Principles of Curing Process. Typical manufacturing techniques suitable for airframe production. Principles of mould design and material selection. Specific requirements for mock-ups and moulds induced by the curing conditions and forms of reinforcement. Manufacturing stresses and deformations. Manufacturing flaws. Typical designs of composite parts of airframes.

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Methods for concentrated load transfer – principles of fitting design. Fundamentals of stress analysis. Classical Lamination Theory (constitutive equations). Strength criteria. Certification process. Service induced deterioration of mechanical properties of polymeric laminates and parts of composite airframes. Basics of FEM application for stress analysis of laminates.

Additional remarks (by course staff):

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Sylabus

Course name:	**Control in Aerospace**
Course name in other language:	
Short name:	**CAS**
Course number:	**ML.ANK389**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Robert Głębocki**

ECTS:	**3**	Number of hours:	[Lc, T, Lb, P, S,]
Course level:	**Intermediate**	weekly:	[**2,** 0, 0, 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[**30,** 0, 0, 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Contents - short:

To learn abort designing aeronautics and astronautics automatic control systems and methods.

Bibliography:

Roy Kangton
Stability and control of aircraft systems

Course results:

After completing his course the students will be able to identify aircraft dynamics and design control system for selected object.

Grading criteria:

e.g. , 60% class tests, 40% home project
Practical work: e.g., Software project of aircraft automatic SISO control system

Detailed contents:

Control methods used in aeronautics and astronautics (airplanes, helicopters, rockets). Navigation units influence on control systems.
Aircraft actuators' dynamics.
Identification of dynamics of aircraft control systems (first and second order systems)
Automatic control (PID control, Lead Lag control, unconventional control algorithms)
Aircraft control systems designing
Aircraft systems (SAS, CAS, FBW)

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Sylabus

Course name:	**Dynamics of Flight**
Course name in other language:	
Short name:	**DOF**
Course number:	**ML.ANK312**
Course language:	**English**
Responsible for the course:	**dr inż. Piotr Lichota**

ECTS:	**3**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[**2,**	0,	0,	0,	0,]
Form of grading:	**Exam**	by semester:	[**30,**	0,	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Recommended prerequisites:

Mechanics 1 (ML.ANW108), Mechanics II (ML.ANW115)

Contents - short:

theory and numerical problems of dynamics of flight

Bibliography:

1. Ashley A.: “Engineering analysis of flight vehicles”. Addison-Wesley Publishing Company, 1974.
2. Babister A. W.: “Aircraft dynamic stability and response”. Pergamon Press, 1980.
3. Cook M. V.: “Flight dynamics principles”. Elsevier, 1997, 2007, 2008.
4. Etkin B.: “Dynamics of atmospheric flight”. John Wiley, 1972.
5. Mcruer D., Ashkenas J., Graham D.: “Aircraft dynamics and automatic control”. Princeton University Press, 1973.
6. Padfield G. D.: “Helicopter flight dynamics. the theory and application of flying qualities and simulation modelling”. Backwell Science Ltd. 1996.
7. Pamadi B. N.: “Performance, stability, dynamics and control of airplanes”. AIAA Education Series, 2004.
8. Roskam J.: “Airplane flight dynamics and automatic flight controls”. DAR, 2003.
9. Saunders G. H.: “Dynamics of helicopter flight”. John Wiley, 1975.
10. Seckel E.: “Stability and control of airplanes and helicopters”. Academic Press, 1964.
11. Stevens B. l., Lewis F. l.: “Aircraft control and simulation”. John Wiley, 1992.

Course results:

After completing his course the students will be able to determine the dynamic characteristics of rigid flight vehicles.

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Grading criteria:

Home individual project during semester, final written examination

Detailed contents:

General equations of 6 degrees of freedom motion for rigid flight vehicles. Aerodynamic and propulsive terms for equations of motion - aerodynamic derivatives. Linearized and dimensionless equations of motion. Solution of the small-perturbation equations of motion. Dynamic stability of flight vehicles. Handling qualities. Response to control. Passive and active methods of stabilization of flight vehicles - principles of the automatic stabilization of flight vehicles.

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Sylabus

Course name:	**Fatigue and Aircraft Diagnostic Systems**
Course name in other language:	
Short name:	**FADS**
Course number:	**ML.ANS652**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Mirosław Rodzewicz**

ECTS:	**4**	Number of hours:	[Lc, T, Lb, P, S,]
Course level:	**Intermediate**	weekly:	[**2,** 0, **1,** 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[**30,** 0, **15,** 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

Acquiring skills in structural materials selection following strength, technological and usable factors, composite structures properties design, and engineers methods of their strength evaluations

Bibliography:

1. Jaap Schijve :" Fatigue of Structures and Materials Book Description", Hardcover 2009, 2nd Edition
2. N. G. Belly: Fatigue and damage tollerance tests of aircraft structures,, CWA 22 Corporation, 2001
3. B. Harris - edition: "Fatigue in composites", CRC Press, Cambridge England, 2003.

Grading criteria:

Based on tests results

Detailed contents:

Fatigue loads and their sources. Fatigue characterization of materials applied in aeronautical structures. Stress concentration - Influence of notches. Fatigue degradation of aeronautical structures and damage cumulation theories. Phases of fatigue degradation. Residual strength of fatigued structures, and fatigue life of the structure. Systems of aircraft maintenance in aspect of fatigue durability. Diagnostics – defectoscopy methods and systems. Diagnostic procedures in airlines. Fatigue tests in aircraft certification processes.

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Sylabus

Course name:	**Heat Transfer in Aerospace**
Course name in other language:	
Short name:	**HTIA**
Course number:	**ML.ANK425**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Maciej Jaworski**

ECTS:	**4**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[**3,**	0,	0,	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**45,**	0,	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Recommended prerequisites:

Fluid Mechanics 1 (ML.ANW122), Thermodynamics 1 (ML.ANW116)

Contents - short:

To learn about basic and complex heat transfer mechanisms, as well as fundamental laws governing these physical processes. To introduce several analytical and numerical methods available for solving heat transfer problems. To learn about particular heat transfer processes, important from the point of view of aerospace engineering.

Bibliography:

1) Cengel Y.A.: Heat and mass transfer, a practical approach, McGraw-Hill, 2007
2) Bejan A., Kraus A.D.: Heat Transfer Handbook, John Wiley & Sons, 2003.

Course results:

After completing his course the students will be able to identify heat transfer problem, apply proper mathematical model and find the solution; he/she will also understand complex, contemporary heat transfer technology used especially in aerospace engineering

Grading criteria:

Three tests during the course; each test contains both theoretical and practical problems,

Detailed contents:

Basic mechanisms of heat transfer – conduction, convection, radiation; fundamental laws,
Thermophysical properties of substances
Conduction: energy conservation equation; physical, boundary and initial conditions,
Steady-state conduction; thermal resistance concept; extended surfaces,
Transient conduction: lumped thermal capacity model, general solution of transient heat conduction, conduction with periodic boundary conditions,

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Introduction to numerical methods in heat transfer
Convection heat transfer: free and forced confection; external and internal flow, correlations for the evaluation of heat transfer coefficient,
Convection heat transfer: supersonic external flows, ablation, transpiration and effusion cooling,
Convection heat transfer: boiling and condensation, heat pipes, two-phase flow cooling techniques,
Radiation: basic equation, radiation resistance concept.

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Sylabus

Course name:	**Intermediate Masters Project**
Course name in other language:	
Short name:	**IMPRO**
Course number:	**ML.ANK491**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Paweł Pyrzanowski**

ECTS:	**6**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[0,	0,	0,	**6,**	0,]
Form of grading:	**Exam**	by semester:	[0,	0,	0,	**90,**	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Energetyka	**Nuclear Power Engineering**	**graduate studies, full time**	**3**
	Power engineering	**graduate studies, full time**	**2**
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

Solution of a given problem and the elaboration of a short report on the subject of performed work.

Bibliography:

Books and textbooks, scientific journals, the Internet.

Course results:

Gaining the ability: to solve problems, perform selection of relevant literature, choosing research methods, presentation of obtained results and its critical analysis.

Grading criteria:

Evaluation criteria: problem statement, literature overview, problem solution and its written presentation.

Detailed contents:

Detailed contents depend on the topic and the nature of work (design-prototyping, computational, experimental).

Additional remarks (by course staff):

The scope of work is terms to consultation between the student and his individual supervisor. The topic must be consistent with study programme and specialisation.

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Sylabus

Course name:	**Master Diploma Seminar**
Course name in other language:	**Seminarium dyplomowe magisterskie**
Short name:	**MDS**
Course number:	**ML.ANW138**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Paweł Pyrzanowski**

ECTS:	**2**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Advanced**	weekly:	[0,	0,	0,	**2,**	0,]
Form of grading:	**Exam**	by semester:	[0,	0,	0,	**30,**	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Energetyka	**-**	**graduate studies, full time**	**3**
	Nuclear Power Engineering	**graduate studies, full time**	**4**
	Power engineering	**graduate studies, full time**	**3**
Lotnictwo i Kosmonautyka	**-**	**graduate studies, full time**	**3**
	Aerospace engineering	**graduate studies, full time**	**3**

Contents - short:

Gaining skills of information gathering and its critical analysis; learning presentation skills.

Bibliography:

Books, textbooks, scientific journals, the Internet

Course results:

Gaining the ability of information gathering, and performing its critical assessment (especially concerning information obtained from the Internet). Learning how to prepare short and concise presentations and how to present in limited time. Learning how to defend a thesis in front of an audience.

Grading criteria:

The elements that are subject to evaluation include: the quality of collected information, quality of elaborated analysis, especially the critical discussion of collected data, and quality of the given presentation. It is recommended that the presentation is conducted during a student group meeting, and the students should contribute to its evaluation.

Detailed contents:

It is recommended that the subject is completed in two steps:

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1. Collecting materials on the given subject with the aid of all available information sources: including books, textbooks, journals and the Internet. The collected material must be analysed and summarised in the form of a short report containing references to the literature sources used. This part should be conducted under the supervision of the advisor and its progress must be controlled during individual meetings. An important part of this stage is a critical analysis of the collected material and its relation to the knowledge gained during studies. It is required to use both domestic and international source materials.
2. Work presentation. Results presentation must be performed in front of a bigger audience during a student group seminar. Each of the students will be given 10-15 minutes of presentation time, followed with questions stated by the seminar participants. This stage is considered preparation to the upcoming thesis defense.

Additional remarks (by course staff):

The seminar should be prepared under the supervision of a scientific supervisor. It must follow the diploma thesis themes. The seminar should match the area of studies programme and specialisation.

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Sylabus

Course name:	**Master Diploma Thesis**
Course name in other language:	
Short name:	**MDT**
Course number:	**ML.ANW137**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Paweł Pyrzanowski**

ECTS:	**20**	Number of hours:	[	Lc,	T,	Lb,	P,	S,]
Course level:	**Advanced**	weekly:	[	0,	0,	0,	**15,**	0,]
Form of grading:	**Exam**	by semester:	[	0,	0,	0,	**225,**	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Energetyka	**-**	**graduate studies, full time**	**3**
	Nuclear Power Engineering	**graduate studies, full time**	**4**
	Power engineering	**graduate studies, full time**	**3**
Lotnictwo i Kosmonautyka	**-**	**graduate studies, full time**	**3**
	Aerospace engineering	**graduate studies, full time**	**3**

Contents - short:

Synthesis of engineering knowledge acquired during first and second degree studies. Gaining the ability of solving the given problem and preparing the report.

Bibliography:

Books, textbooks, scientific journals, the Internet

Course results:

Gaining the ability: - to solve the research problem , - perform selection of relevant literature, - choosing research methods, - presentation of obtained results and its critical analysis.
Detailed specification depend on the topic of work.

Grading criteria:

The promoter and reviewer verify the realisation of task given to the student, they fill out the thesis assessment forms. With positive evaluation the student is permitted to diploma defence, the final grade is decided by the commission.

Detailed contents:

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Detailed contents depend on the topic and the nature of work (design-prototyping, computational, experimental).

Additional remarks (by course staff):

The scope of diploma work is terms to consultation between the student and his individual supervisor. The topic must be consistent with study programme and specialisation
The elaborated thesis report is evaluated. The student is permitted to attend the diploma exam (and the diploma defence) if he/she completed the required study programme and the other requirements specified in study regulations are fulfilled.

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Sylabus

Course name:	**Mechanics of Thin-Walled Structures**
Course name in other language:	
Short name:	**MTS**
Course number:	**ML.ANS642**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. inż. Adam Dacko**

ECTS:	**3**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Advanced**	weekly:	[**1,**	**1,**	**1,**	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**15,**	**15,**	**15,**	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Recommended prerequisites:

Mechanics of Structures 1 (ML.ANW117), Mechanics of Structures 2 (ML.ANK427)

Contents - short:

To provide engineers insight into specifics of structural analysis of thin walled structures. The course gives foundations of work of thin-walled beams, bending effects in shells, axisymmetrical pressure vessels and structures, buckling and post-buckling analysis

Bibliography:

1. Hearn – Mechanics of Materials
2. Case, Chilver, Ross - Strength of Materials and Structures
3. Timoshenko – Theory of plates and shells,
4. Timoshenko, Gere – Theory of elastic stability,
5. Gjelsvik – The Theory of Thin Walled Bars

Course results:

After completing his course the students will be able to apply a correct approach for analysis of thin walled structures. That means choose a proper model and analysis methods applying to this model, as well as estimation of obtained results. Critical assessment of outcome of analysis is the basis of sound engineering approach.

Grading criteria:

Home assignments, Test problems

Detailed contents:

Plate bending theory (Kirchhoff). Small and large deflections.
Out of plane loads. In plane load – rotating disks and compound pipes.
Thin-walled beams – open and closed section.

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Shell theory (Kirchhoff-Love). Small and large deflections.
Shell, monocoque and semi-monocoque models.
Stability of structures (energy approach). Post-buckling behavior.

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Sylabus

Course name:	**Optimization in Aircraft Design**
Course name in other language:	
Short name:	**OIAD**
Course number:	**ML.ANK306**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. Tomasz Goetzendorf-Grabowski**

ECTS:	**3**	Number of hours:	[	Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[	**2,**	0,	**1,**	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[	**30,**	0,	**15,**	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**3**

Recommended prerequisites:
Aircraft Design 1 (ML.ANK307)

Contents - short:
Basic knowledge of mathematical methods of optimization
Basic skills of formulating and solving of simply optimization problems in aircraft design

Bibliography:
1. D.P. Raymer, Aircraft Design: A Conceptual Approach, AIAA Eductaion Series
2. G.N. Vanderplaats: Numerical Optimization Techniques For Engineering Design, McGraw Hill
3. Ross Baldick: Applied Optimization, Cambridge University Press, 2006
Selected lectures in electronic form (web site)

Course results:
After subject is completed student should:
• have the basic knowledge of mathematical methods of optimization
• be able to solve simple optimization problems in aircraft design

Grading criteria:
Projects and test

Detailed contents:
Convergent and divergent spiral in design process. Sizing in aircraft design. The most important elements taken under consideration during optimization (geometry, aerodynamics, propulsion system, mission and performance, structure, stability and FCS, etc.) Optimal wing load and thrust load. Optimization in design of specific type of aircraft (combat, firefighting, GA, etc.) Selection of objective function. Mathematical and numerical methods in optimization.

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Additional remarks (by course staff):

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Sylabus

Course name:	**Partial Differential Equations**
Course name in other language:	
Short name:	**PDE**
Course number:	**ML.ANK481A**
Course language:	**English**
Responsible for the course:	**dr Paweł Wójcicki**

ECTS:	**4**	Number of hours:	[Lc, T, Lb, P, S,]
:		weekly:	[**2,** **1,** 0, 0, 0,]
Form of grading:	**Exam**	by semester:	[**30,** **15,** 0, 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Energetyka	**Nuclear Power Engineering**	**graduate studies, full time**	**1**
	Power engineering	**graduate studies, full time**	**1**
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

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Sylabus

Course name:	**Physics 2**
Course name in other language:	
Short name:	**PHYS2**
Course number:	**ML.ANK480**
Course language:	**English**
Responsible for the course:	**dr inż. Daniel Budaszewski**

ECTS:	**2**	Number of hours:	[Lc, T, Lb, P, S,]
Course level:	**Intermediate**	weekly:	[**2,** 0, 0, 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[**30,** 0, 0, 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Energetyka	**Nuclear Power Engineering**	**graduate studies, full time**	**2**
	Power engineering	**graduate studies, full time**	**2**
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**
Mechanika i Budowa Maszyn	**Computer Aided Engineering_specjalność**	**undergraduate, full time**	**7**

Contents - short:

The student should have a good working knowledge of mathematics, which will be required in order to work problems. The course seeks to provide a reasonable blend of theory (concepts of physics) and problem-solving techniques based on theory. The lectures are primarily concerned with developing the concepts of physics and working through a few problems involving application of these concepts.
It is recommended that you keep up with the class on a steady basis and see us if there are things that you do not understand.

Bibliography:

The reading schedule will be given on the class and continually updated

Course results:

After completing his course the students will understand the basics of the relativity and the optics. This knowledge gives them possibility to project simple optics components and units.

Grading criteria:

The final written exam will be cumulative over all material covered during the semester. (grade: 100% exam)

Detailed contents:

Relativity
Time Dilatation

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Length Contraction
The Lorentz Transformation
Relativistic Energy and Momentum
Optics
Review of Electricity and Magnetism (Gauss' Law, Ampère's Law, Faraday's Law, Maxwell's Equations, The Wave Equation)
Plane Waves in Isotropic Media
Energy Flux (Energy Flux, Intensity)
Polarized Light (The Wave Equation as an Eigenvalue Problem, The Polarization Ellipse, Linear Polarization, Circular Polarization)
Fresnel Reflection (π polarization, σ Polarization, Total Internal Reflection (TIR))
Light Propagation in Uniaxial Media (The Dielectric Constant Tensor, Solution of Maxwell's Equation for the Propagating Eigenmodes, The Non-propagating Mode, The Ordinary Wave, The Extraordinary Wave)
Dispersion (Dissipation, Dispersion)
Interference
Diffraction (Single and Double Slit Diffraction, Young Experiment, Diffraction Grating, Holography)
Nonlinear Susceptibility
Gaussian Beams

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Sylabus

Course name:	**Physics of the Atmosphere**
Course name in other language:	
Short name:	**PHYSAT**
Course number:	**ML.ANK321A**
Course language:	**English**
Responsible for the course:	**prof. nzw. dr hab. Tomasz Goetzendorf-Grabowski**

ECTS:	**2**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
:		weekly:	[**1,**	0,	0,	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**15,**	0,	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

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Sylabus

Course name:	**Sensors and Measurements Systems**
Course name in other language:	
Short name:	**SMS**
Course number:	**ML.ANS511A**
Course language:	**English**
Responsible for the course:	**dr inż. Przemysław Bibik**

ECTS:	**3**	Number of hours:	[Lc, T, Lb, P, S,]
:		weekly:	[**1,** 0, **1,** 0, 0,]
Form of grading:	**Continous assesment**	by semester:	[**15,** 0, **15,** 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

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Sylabus

Course name:	**Signals and Identification Methods**
Course name in other language:	
Short name:	**SIM**
Course number:	**ML.ANK495**
Course language:	**English**
Responsible for the course:	**prof. dr hab. inż. Janusz Narkiewicz**

ECTS:	**3**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Intermediate**	weekly:	[**1,**	**1,**	0,	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**15,**	**15,**	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Contents - short:

The background of methods for building reliable models of various systems and their components. System identification methods. Basic signal processing.

Bibliography:

1. Klein V., Morelli E.A., “Aircraft System Identification Theory and Practice”, AIAA Educational Series, 2006.
web site materials.

Course results:

Ability to implement the suitable methods for signal processing, model building and its parameter identification and estimation.

Grading criteria:

Tests during semester. Project - application of selected identification methods.
Self study - Matlab / Simulink programming skills adequate for completing homework.

Detailed contents:

Lecture: Basic definitions: signal, model, identification, estimation. Deterministic and stochastic signals. Transformation from time to frequency domain. Analog / Digital conversion. Filters: analog and digital, filter optimization. Signal coding. Modelling of static and dynamic processes. Estimation theory. The least squares method for estimation. Experiment planning. Data processing errors and their estimation.
Tutorials: Examples of topic presented during lectures.

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Date 06.03.2019

Sylabus

Course name:	**Space Technologies**
Course name in other language:	
Short name:	**STECH**
Course number:	**ML.ANK398**
Course language:	**English**
Responsible for the course:	**dr inż. Arkadiusz Kobiera**

ECTS:	**2**	Number of hours:	[Lc, T, Lb, P, S,]
Course level:	**Intermediate**	weekly:	[**2,** 0, 0, 0, 0,]
Form of grading:	**Exam**	by semester:	[**30,** 0, 0, 0, 0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**1**

Recommended prerequisites:

Astronautics (ML.ANK468), Astronautyka (ML.NK468)

Contents - short:

Aquisition of knowledge about main principles of spacecraft design, space mission course and ground segment

Bibliography:

1. P. Fortescue, J. Stark and G. Swinerd, Spacecraft systems engineering, Wiley, Chichester, 2007
2. C. D. Brown, Elements of spacecraft design, AIAA, Reston, 2002
3. Written materials on the Department's Web site.
4. Further Readings: Aviation Week, Lotnictwo, Postępy Astronatuki, and other scientific and popular science journals

Course results:

Determining of requirements for spacecraft in respect to kind of space mission; Calculation of parameters of orbits; Calculation of basic parameters of satellite and launcher subsytems

Grading criteria:

Exam

Detailed contents:

Space environment; Orbit parameters; Spacecraft as a technical system; Launchers, Main subsystem of satellites: mechanical structure, mechanisms, power system, thermal system, attitude and orbit control systems, telemetry and control systems; Manned spacecrafts; Ground stations; Applications of space technology

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Sylabus

Course name:	**Structural Analysis of Aero Engines**
Course name in other language:	
Short name:	**SAAE**
Course number:	**ML.ANS650**
Course language:	**English**
Responsible for the course:	**prof. dr hab. inż. Marek Żochowski**

ECTS:	**4**	Number of hours:	[Lc,	T,	Lb,	P,	S,]
Course level:	**Advanced**	weekly:	[**2,**	0,	0,	0,	0,]
Form of grading:	**Continous assesment**	by semester:	[**30,**	0,	0,	0,	0,]

Field of Study:	Field of Specialization:	Study level:	Recommended semester:
Lotnictwo i Kosmonautyka	**Aerospace engineering**	**graduate studies, full time**	**2**

Recommended prerequisites:

Mechanics of Structures 1 (ML.ANW117), Mechanics of Structures 2 (ML.ANK427)

Contents - short:

Loadings: mechanical, thermal, vibrations. Strength requirements, materials and its mechanical properties as a function of temperature. Methods of strength calculations of blades, rotating discs, circular plates, cylindrical shells mechanically and thermally loaded. Bending and torsional vibrations.

Bibliography:

1. Bijak-Żochowski M., Jaworski A., Krzesiński G., Zagrajek T.: Mechanika Materiałów i Konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2006.
2.Brzoska Z.: Wytrzymałość Materiałów, PWN, Warszawa, 1979.
3. John Hearn “Mechanics of Structures”

Course results:

Ability of strength calculations of aircraft engines elements within elastic range.

Grading criteria:

Homeworks, examination

Additional remarks (by course staff):
