Warsaw University of Technology

Faculty of Power and Aeronautical Engineering

CATALOGUE OF COURSES

Graduate studies (M.Sc. degree)
TOK 2006

Warsaw 2011
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:

<table>
<thead>
<tr>
<th>Field of Studies</th>
<th>Specialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td>Power Engineering</td>
<td>Power Engineering</td>
</tr>
</tbody>
</table>

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

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 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.

<table>
<thead>
<tr>
<th>M. Sc. Programme</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration for semester</td>
<td>16</td>
<td>48</td>
<td>80</td>
</tr>
</tbody>
</table>
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 nine 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,
- 4-week internship (in industry)
- 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.

\[
Average\ grade = \frac{\sum_{i=1}^{Z} g_i \cdot O_i}{\sum_{i=1}^{Z} g_i}
\]

\(Z\) – 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:

- \( \text{Lc} \) – Lecture
- \( \text{T} \) – Tutorial
- \( \text{Lb} \) – Laboratory
- \( \text{P} \) – Project
- \( \text{S} \) – Seminar
## Field of Study Lotnictwo i Kosmonautyka

<table>
<thead>
<tr>
<th>Aerospace Engineering</th>
<th>Semester 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Semester 2</td>
</tr>
<tr>
<td></td>
<td>Semester 3</td>
</tr>
</tbody>
</table>
Field of Study Lotnictwo i Kosmonautyka  
Field of Specialization Aerospace Engineering  
Semester 1

List of field of study courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course number</th>
<th>Course name</th>
<th>Lc</th>
<th>T</th>
<th>Lb</th>
<th>P</th>
<th>S</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ANK323</td>
<td>Advanced Computational Fluid Dynamics</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>ANS646</td>
<td>Aircraft systems laboratory</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>ANS520</td>
<td>Composite Materials in Aerospace</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>ANK389</td>
<td>Control in Aerospace</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>ANK312</td>
<td>Dynamics of Flight</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>ANK425</td>
<td>Heat Transfer in Aerospace</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>ANS642</td>
<td>Mechanics of Thin-Walled Structures</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>ANK481</td>
<td>Partial differential equations</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>9.</td>
<td>ANK321</td>
<td>Physics of the Atmosphere</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>ANK398</td>
<td>Space Technologies</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Field of Study Lotnictwo i Kosmonautyka  
Field of Specialization Aerospace Engineering  
Semester 2

List of field of study courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course number</th>
<th>Course name</th>
<th>Lc</th>
<th>T</th>
<th>Lb</th>
<th>P</th>
<th>S</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ANS600</td>
<td>Advanced Aero Engines Laboratory</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>ANK496</td>
<td>Aircraft maintenance management</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>ANS647</td>
<td>Attitude and navigation systems</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>ANS652</td>
<td>Fatigue and aircraft diagnostic systems</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>ANK491</td>
<td>Intermediate Masters project</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>6.</td>
<td>ANK480</td>
<td>Physics 2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>ANS511</td>
<td>Sensors and measurements systems</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>ANK495</td>
<td>Signals and identification methods</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>ANS650</td>
<td>Structural analysis of aero engines</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
Field of Study Lotnictwo i Kosmonautyka
Field of Specialization Aerospace Engineering
Semester 3

List of common courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course number</th>
<th>Course name</th>
<th>Lc</th>
<th>T</th>
<th>Lb</th>
<th>P</th>
<th>S</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ANW138</td>
<td>Master Diploma Seminar</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>ANW137</td>
<td>Master Diploma Thesis</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

List of field of study courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course number</th>
<th>Course name</th>
<th>Lc</th>
<th>T</th>
<th>Lb</th>
<th>P</th>
<th>S</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ANK306</td>
<td>Optimization in Aircraft Design</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
SYLLABUS

Course name: Advanced Aero Engines Laboratory
Course name in other language: Zawansowane laboratorium silników lotniczych
Short name: AEL
Course number: ANS600
Course language: English
Responsible for the course: prof. dr hab. inż. Marian Gieras
ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: intermediate
weekly: [ 0, 0, 2, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 0, 0, 2, 0, 0 ]

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

Contents - short:

Bibliography:

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

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.
SYLLABUS

**Course name:** Advanced Computational Fluid Dynamics

**Course name in other language:** ACFD

**Short name:** ANK323

**Course language:** English

**Responsible for the course:** prof. dr hab. inż. Jacek Rokicki

**ECTS:** 3

**Number of hours:** [ Lc, T, Lb, P, S ]

**Course level:** basic

**weekly:** [ 2, 0, 1, 0, 0 ]

**Form of grading:** Continous assesment

**by semester:** [ 30, 0, 15, 0, 0 ]

**Field of Study:** Lotnictwo i Kosmonautyka

**Field of Specialization:** Aerospace Engineering

**Study level:** graduate studies, full time

**Recommended semester:** 1

**Prerequisits:**
- Computer science 2 (ANW114)
- Fluid mechanics 1 (ANW122)
- Fluid mechanics 3 (ANK341)

**Contents - short:**
To familiarize the students with the algorithms and advanced methods of computational fluid dynamics

**Bibliography:**
3. J. Blazek, Computational Fluid Dynamics: Principles and Applications, 2005

**Course results:**
After completing this course the students will be able to understand advanced algorithms of CFD as well as perform advanced simulations using commercial CFD code (mesh generation, setting up boundary and initial conditions, monitoring simulations, assessment and visualization of results)

**Grading criteria:**
1 lecture test (60 points), lab. continuous assignment (20 points), lab. test (20 points), resulting mark: (30-49 – N, 50-59 – 3.0, 60-69 – 3.5, 70-79 – 4.0, 80-89 – 4.5, 90-100 – 5.0), if necessary the optional final exam may override the score received during the lecture test

**Practical work:** lab work

**Detailed contents:**
SYLLABUS

Course name: Aircraft maintenance management
Course name in other language: AMM
Short name: ANK496
Course language: English
Responsible for the course: dr inż. Kamila Kustoń
ECTS: 2
Course level: basic
Form of grading: Continuous assessment

Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 0, 1, 0, 0, 0 ]
by semester: [ 0, 15, 0, 0, 0 ]

Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 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:
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:
es

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,

Additional remarks (by course staff):
SYLLABUS

Course name: Aircraft systems laboratory
Course name in other language: ASL
Short name: ANS646
Course number: English
Course language: dr inż. Przemysław Bibik
Responsible for the course:
ECTS: 3
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 0, 0, 3, 0, 0 ]
Form of grading: Continous assesment
by semester: [ 0, 0, 45, 0, 0 ]
Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 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.
SYLLABUS

Course name: Attitude and navigation systems
Course name in other language: Układy nawigacji i orientacji przestrzennej
Short name: ANS
Course number: ANS647
Course language: English
Responsible for the course: prof. dr hab. inż. Janusz Narkiewicz

ECTS: 4
Course level: basic
Form of grading: Continuous assessment

Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 1, 1, 0, 1, 0 ]
by semester: [ 15, 15, 0, 15, 0 ]

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

Contents - short:
Systems for position and attitude determination used in aerospace and other fields of technology.

Bibliography:
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:
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.
## SYLLABUS

**Course name:** Composite Materials in Aerospace  
**Course name in other language:** Kompozyty w konstrukcjach lotniczych

**Short name:** CMA  
**Course number:** ANS520  
**Course language:** English  
**Responsible for the course:** prof. dr hab. inż. Piotr Czarnocki

**ECTS:** 3  
**Number of hours:**  
**Course level:** basic  
**Form of grading:** Continuous assessment  
**Weekly:** [2, 0, 0, 0, 0]  
**By semester:** [30, 0, 0, 0, 0]

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

**Prerequisites:**  
Budowa i projektowanie obiektów latających 1 (NK307)

**Contents - short:**  
Fundamental engineering knowledge about possible application of composite materials with polymeric matrixes for airframes of modern aircrafts.

**Bibliography:**  
1) Book 1: H.D. Middleton, “Composite materials in aircraft structure”  
3) Book 3: M. C-Y Niu, “Composite airframe structures”

Further Readings:  
- will be provided by lecturer

**Course results:**  
Principles of design and manufacturing of composite airframes for modern aircrafts.

**Grading criteria:**  
Average project mark

**Detailed contents:**  
SYLLABUS

Course name: Control in Aerospace
Course name in other language: CAS
Short name: ANK389
Course language: English
Responsible for the course: dr inż. Robert Głębocki
ECTS: 3
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 0, 0, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 30, 0, 0, 0, 0 ]

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

Contents - short:
To learn about 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)
SYLLABUS

Course name: Dynamics of Flight
Course name in other language: DOF
Short name: ANK312
Course number: 3
Course language: English
Responsible for the course: dr inż. Maria Złocka

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

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

Prerequisites:
Mechanics 1 (ANW108) , Mechanics 2 (ANW115)

Contents - short:
theory and numerical problems of dynamics of flight

Bibliography:

Course results:
After completing his course the students will be able to determine the dynamic characteristics of rigid flight vehicles.
Grading criteria:
Home individual project during semester, final written examination

Detailed contents:
**SYLLABUS**

**Course name:** Fatigue and aircraft diagnostic systems

**Course name in other language:** FADS

**Short name:** 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:** basic

**Weekly:** [ 2, 0, 1, 0, 0 ]

**Form of grading:** Continous assessment

**By semester:** [ 30, 0, 15, 0, 0 ]

**Field of Study:** Lotnictwo i Kosmonautyka

**Field of Specialization:** Aerospace Engineering

**Study level:** graduate studies, full time

**Recommended semester:** 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:**
2. N. G. Belly: Fatigue and damage tolerance tests of aircraft structures,, CWA 22 Corporation, 2001

**Grading criteria:** Based on tests results

**SYLLABUS**

<table>
<thead>
<tr>
<th>Course name:</th>
<th>Heat Transfer in Aerospace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course name in other language:</td>
<td></td>
</tr>
<tr>
<td>Short name:</td>
<td>HTIA</td>
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<tr>
<td>Course number:</td>
<td>ANK425</td>
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<tr>
<td>Responsible for the course:</td>
<td>dr inż. Maciej Jaworski</td>
</tr>
<tr>
<td>ECTS:</td>
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<tr>
<td>Number of hours:</td>
<td>[ Lc, T, Lb, P, S ]</td>
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<tr>
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<tr>
<td>Form of grading:</td>
<td>Continous assessment</td>
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<tr>
<td>by semester:</td>
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<td>Field of Study:</td>
<td>Field of Specialization:</td>
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<tr>
<td>Lotnictwo i Kosmonautyka</td>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td>Study level:</td>
<td>graduate studies, full</td>
</tr>
<tr>
<td>Recommended semester:</td>
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**Prerequisites:**
Fluid mechanics 1 (ANW122), Thermodynamics 1 (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:**

**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,
Introduction to numerical methods in heat transfer
Convection heat transfer: free and forced convection; 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.
SYLLABUS

Course name: Intermediate Masters project
Course name in other language: Praca przejściowa magisterska
Short name: IMPRO
Course number: ANK491
Course language: English
Responsible for the course: prof. dr hab. inż. Paweł Pyrzanowski
ECTS: 6
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 0, 0, 0, 6, 0 ]
Form of grading: Exam
by semester: [ 0, 0, 0, 90, 0 ]

Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 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.
Course name: Master Diploma Seminar
Course name in other language: Seminarium dyplomowe magisterskie
Short name: MDS
Course number: ANW138
Course language: English
Responsible for the course: prof. dr hab. inż. Paweł Pyrzanowski
ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: advanced
weekly: [ 0, 0, 0, 0, 2 ]
Form of grading: Exam
by semester: [ 0, 0, 0, 0, 30 ]
Field of Study: Field of Specialization:
Energetyka - graduate studies, full time
Lotnictwo i Kosmonautyka - graduate studies, full time
Recommended semester: 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:
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.
SYLLABUS

Course name: Master Diploma Thesis
Course name in other language: Przygotowanie pracy dyplomowej magisterskiej
Short name: MDT
Course number: ANW137
Course language: English
Responsible for the course: prof. 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, 45, 0 ]
Field of Study: Field of Specialization: Study level: Recommended semester:
Energetyka - graduate studies, full time 3
Lotnictwo i Kosmonautyka - 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:
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.
Course name: Mechanics of Thin-Walled Structures
Course name in other language: Wytrzymałość konstrukcji cienkościennych
Short name: MTS
Course number: ANS642
Course language: English
Responsible for the course: dr inż. Adam Dacko
ECTS: 3
Number of hours: [ Lc, T, Lb, P, S ]
Course level: intermediate
weekly: [ 1, 1, 1, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 15, 15, 15, 0, 0 ]
Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 1
Prerequisits:
Mechanics of structures 1 (ANW117), Mechanics of structures 2 (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.
Shell theory (Kirchhoff-Love). Small and large deflections.
Shell, monocoque and semi-monocoque models.
Course name: Optimization in Aircraft Design
Course name in other language: Optymalizacja w projektowaniu statków powietrznych
Short name: OIAD
Course number: ANK306
Course language: English
Responsible for the course: dr inż. Tomasz Goetzendorf-Grabowski
ECTS: 3
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 0, 1, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 30, 0, 15, 0, 0 ]
Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 3
Prerequisites:
Aircraft Design 1 (ANK307)
Contents - short:
Basic knowledge of mathematical methods of optimization
Basic skills of formulating and solving of simply optimization problems in aircraft design
Bibliography:
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.
SYLLABUS

Course name: Partial differential equations
Course name in other language: PDE
Short name: ANK481
Course number: English
Course language:
Responsibility for the course: prof. dr hab. inż. Andrzej Fryszkowski
ECTS: 5
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 1, 0, 0, 0 ]
Form of grading: Exam
by semester: [ 30, 15, 0, 0, 0 ]

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

Contents - short:
Provide the students with the basic types of PDE’s, methods of solving PDE’s and their applications. Basic applications can be illustrated during laboratories.

Bibliography:

Course results:
After completing the course the students will be able to specify the type of PDE, solve it, interpret the solutions and implement them in practical problems.

Grading criteria:
60% final exam, 40% continuous assessment based on tutorial work.
Practical work: e.g., Project/laboratory classes, where students will design and implement a simple problems in PDE’s

Detailed contents:
1. Fourier analysis
   a) the Fourier series of a function; applications to forced oscillation and resonance;
   b) the Fourier integral, sine and cosine integrals; Computer calculations of Fourier coefficients;
   c) Fourier transforms: definition; properties; calculation.
2. PDE’s of the first order: the existence of a local solution; linear PDE’s; quasi-linear PDE’s and their geometrical interpretation.
3. Derivation of the wave and heat equation and types of problems.
4. The d’Alembert Solutions of the wave equation.
5. The Fourier series Solutions of the wave equation.
6. The wave equation for semiinfinite and infinite strings.
7. The Fourier series Solutions of the heat equation.
8. The heat equation for semiinfinite and infinite regions.
Laboratories: application of Mathlaba for solving PDE’s and visualization of solutions.
SYLLABUS

Course name: Physics 2
Course name in other language: PHYS2
Short name: PHYS2
Course number: ANK480
Course language: English
Responsible for the course: dr Piotr Lesiak

ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 0, 0, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 30, 0, 0, 0, 0 ]

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

Mechanika i Budowa
Maszyn
Field of Specialization: Computer Aided Engineering
Study level: undergraduate, full time
Recommended semester: 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
Length Contraction
The Lorentz Transformation
Relativistic Energy and Momentum
Optics
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))
Dispersion (Dissipation, Dispersion)
Interference
Diffraction (Single and Double Slit Diffraction, Young Experiment, Diffraction Grating, Holography)
Nonlinear Susceptibility
Gaussian Beams
SYLLABUS

Course name: Physics of the Atmosphere
Course name in other language: Fizyczne podstawy zagrożeń atmosferycznych
Short name: PHYSAT
Course number: ANK321
Course language: English
Responsible for the course: dr inż. Tomasz Goetzendorf-Grabowski

ECTS: 1
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 1, 0, 0, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 15, 0, 0, 0, 0 ]

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

Contents - short:
Basic knowledge of atmosphere physics
Knowledge about atmosphere phenomena, which create the weather
Knowledge of phenomena that are danger for aircraft

Bibliography:
1. Selected lectures in electronic form (web site)
Materials available on the website:
http://www.meil.pw.edu.pl/add/ADD/Teaching/Subjects/Physics-of-Atmosphere

Course results:
After subject is finished student should:
have the knowledge about basic structure of Earth atmosphere,
have the knowledge about atmospheric phenomena, which impact the weather,
have the knowledge about atmospheric phenomena, which cause danger for flight of aircraft.

Grading criteria:
Test

Detailed contents:
SYLLABUS

Course name: Sensors and measurements systems
Course name in other language: Czujniki i układy pomiarowe
Short name: SMS
Course number: ANS511
Course language: English
Responsible for the course: dr inż. Krzysztof Gajda

ECTS: 3
Course level: basic
Form of grading: Continuous assessment
Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 1, 1, 0, 0, 0 ]
by semester: [ 15, 15, 0, 0, 0 ]

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

Contents - short:
Principles of operation and application of sensors and measurement systems:

Bibliography:
2) LabView – User Manual, National Instruments
3) Mohinder S., Global positioning systems, inertial navigation, and integration, 2001
4) Osiander, R., MEMS and microstructures in aerospace applications ”, 2006
5) Titterton, D., Strapdown Inertial Navigation Technology", 1997

Course results:
After completing the course students will be able principles of operation and applications of measurement methodology with some hands on experience in laboratory

Grading criteria:
80% continuous assessment based on lectures and 20% on laboratory work. 1 test at the end of semester.
Practical work: Laboratory classes, where students will get hands on experience in measurement systems.

Detailed contents:
SYLLABUS

Course name: Signals and identification methods
Course name in other language: Teoria przetwarzania sygnałów i identyfikacja
Short name: SIM
Course number: 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: basic
weekly: [ 1, 1, 0, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 15, 15, 0, 0, 0 ]

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

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

Bibliography:
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:
Tutorials: Examples of topic presented during lectures.
SYLLABUS

Course name: Space Technologies
Course name in other language: STECH
Short name: ANK398
Course number: ANK398
Course language: English
Responsible for the course: dr inż. Arkadiusz Kobiera
ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 0, 0, 0, 0 ]
Form of grading: Exam
by semester: [ 30, 0, 0, 0, 0 ]
Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: Aerospace Engineering
Study level: graduate studies, full time
Recommended semester: 1
Prerequisits:
Astronautics (ANK468), Astronautyka (NK468)

Contents - short:
Aquisition of knowledge about main principles of spacecraft design, space mission course and ground segment

Bibliography:
2. C. D. Brown, Elements of spacecraft design, AIAA, Reston, 2002
4. Further Readings: Aviation Week, Lotnictwo, Postępy Astronautyki, 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
# SYLLABUS

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<tr>
<th>Course name:</th>
<th>Structural analysis of aero engines</th>
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<tr>
<td>Course name in other language:</td>
<td>Strength of engines</td>
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<tr>
<td>Short name:</td>
<td>SAAE</td>
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<td>prof. dr hab. inż. Marek Żochowski</td>
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| ECTS: | 4 |
| Course level: | advanced |
| Form of grading: | Continuous assessment |

| Number of hours: | [ Lc, T, Lb, P, S ] |
| weekly: | [ 2, 0, 0, 0, 0 ] |
| by semester: | [ 30, 0, 0, 0, 0 ] |

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

## Prerequisites:
Mechanics of structures 1 (ANW117), Mechanics of structures 2 (ANK427)

## Contents - short:

## Bibliography:

## Course results:
Ability of strength calculations of aircraft engines elements within elastic range.

## Grading criteria:
Homeworks, examination

## Additional remarks (by course staff):
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