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>
<tr>
<td>Number of collected credits</td>
<td></td>
<td></td>
<td></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.

\[
\text{Average grade} = \frac{\sum_{i \in Z} g_i \cdot O_i}{\sum_{i \in Z} g_i}
\]

\(Z\) – 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
### Field of Study Energetyka

<table>
<thead>
<tr>
<th>Power Engineering</th>
<th>Semester 1</th>
<th>Semester 2</th>
<th>Semester 3</th>
</tr>
</thead>
</table>

Field of Study Energetyka  
Field of Specialization Power Engineering  
Semester 1

List of specialization 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>ANS635</td>
<td>Algorithms and Program of Heat Balances</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>ANK348</td>
<td>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>3.</td>
<td>ANS500</td>
<td>Energy efficiency</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>ANK487</td>
<td>Energy Policy and Law</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>ANK415</td>
<td>Energy transport</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>ANK342</td>
<td>Finite element method 1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>ANK486</td>
<td>Mathematical Modelling and Process</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>ANK347</td>
<td>Numerical methods in heat transfer</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9.</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>
</tbody>
</table>
Field of Study Energetyka
Field of Specialization Power Engineering
Semester 2

<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>ANS645</td>
<td>Advanced Heat Transfer</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>ANS534</td>
<td>Advanced Renewable Energy Sources</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>ANK371</td>
<td>Business Law</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>ANK382</td>
<td>Engineering Project</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>ANS535</td>
<td>Future Power Technologies</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>6.</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>7.</td>
<td>ANK385</td>
<td>Neural networks</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>ANW132</td>
<td>Physics 2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>ANS599</td>
<td>Statistical and Nonequilibrium Thermodynamics</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 Energetyka
Field of Specialization Power 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>20</td>
<td>20</td>
</tr>
</tbody>
</table>

List of specialization 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>ANS559</td>
<td>Information Systems in Management</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>ANK445</td>
<td>Project Management</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Course name: Advanced Heat Transfer
Course name in other language: Zaawansowana Wymiana Ciepła
Short name: AHT
Course number: ANS645
Course language: English
Responsible for the course: prof. dr hab. inż. Piotr Furmański

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

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2

Prerequisites:
Fluid mechanics 1 (ANW122) , Heat transfer 1 (ANK423) , Thermodynamics 1 (ANW116) , Thermodynamics 2 (ANK412) , Thermodynamics 3 (ANK413)

Contents - short:
Knowledge of complex, conjugated heat transfer modes in turbulent fluid flows, two-phase fluid flows, flow through porous media and during phase change. Knowledge of basic equipment used for heat transfer, thermal properties of materials and their measurement.

Bibliography:
6) Materials for students placed on website

Course results:
After completing his course the students will be able to solve complex problems in heat transfer and select heat exchangers for particular applications.

Grading criteria:
solution of two complex problems in heat transfer

Detailed contents:
Lecture:
1. Methods of measurement of heat fluxes and temperature visualisation (infra-red thermography, liquid crystals thermography, thermocolours).
2. Thermal contact resistance.
3. Heat transfer in turbulent and two-phase flows.
4. Heat transfer with phase change (solidification, frost formation, icing).
5. Heat transfer in porous media and suspensions.
6. Thermal insulations and protection against high and low temperatures.
8. Radiation in transparent and semitransparent media.

Tutorials:
1. Examples of calculation of temperature distribution and heat transfer during turbulent flows.
2. Examples of calculations of temperature distribution and heat transfer during two-phase fluid flows.
3. Examples of calculations of temperature distribution and heat transfer during fluid flow in porous media.
3. Examples of calculation of radiative heat transfer in transparent and semitransparent media.
SYLLABUS

Course name: Advanced Renewable Energy Sources
Course name in other language: ARES
Short name: ANS534
Course number: English
Course language: prof. dr hab. inż. Roman Domański
Responsible for the course:
ECTS: 3
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: Energetyka
Field of Specialization: Power Engineering
Study level: undergraduate, full time, graduate studies, full time
Recommended semester: 2, 6

Prerequisites:
Heat transfer 1 (ANK423), Heliotechnika 1 (NS516), Termodynamika (ZNW116)

Contents - short:
Teaching evaluation of renewable energy. Evaluation of implementation possibilities for renewable energy, evaluation of environmental threats related to energy storage and conversion processes, feasibility of individual technologies of renewable energy storage. Presenting new and future renewable energy technologies.

Bibliography:

Course results:
After passing the subject student will be able to analyze renewable energy resources and needs for storage systems. Understand relation between the renewable and fossil and nuclear energy conversion systems, understand the limits for renewables.

Grading criteria:
60% multiple-choice test carried out at the end of the lectures, 40% homework grade.
Own work:
Homework done in teams of 2-3. Subject and form of work (paper, calculations) determined at the beginning of a semester.

Detailed contents:

Additional remarks (by course staff):
Lecture based on Power Point presentations
SYLLABUS

Course name: Algorithms and Program of Heat Balances
Course name in other language: Algorytmy i Programy Bilansów Cieplnych
Short name: APHB
Course number: ANS635
Course language: English
Responsible for the course: dr inż. Jarosław Milewski
ECTS: 2
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: Energy
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1
Prerequisites:
Theory of heat machines (ANK405)

Contents - short:
Power plant scheme as modeling object. Conservation laws of mass, energy and momentum. Review of software which is suitable for power plant evaluation, optimization and case analysis. Practical utilization of the software.

Bibliography:
1) N/A
Further Readings:
1) N/A

Course results:
Experience in advance power plant modelling and optimization.

Grading criteria:
45 minutes for modelling the Gas Turbine Combine Cycle

Detailed contents:
1. Introduction
2. Engineering software review
3. Rotating equipment models
4. Heat transfer models
5. Piping models
6. Control theory models
7. Chemical reactors models
8. Optimization procedures
SYLLABUS

Course name: Business Law
Course name in other language: Prawo gospodarcze
Short name: BL
Course number: ANK371
Course language: English
Responsible for the course: dr Dominik Sypniewski

ECTS: 2
Course level: basic
Form of grading: Continous asessment

Number of hours: 
- Lc: 2
- T: 1
- Lb: 0
- P: 0
- S: 0

by semester: 
- 30
- 15
- 0
- 0
- 0

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2

Contents - short:
The course aims at introducing students basic concepts of business law. Firstly students are familiarized with basic concepts of jurisprudence, introduction to constitutional law, sources of Polish and European business law. The course covers basic concepts of civil and commercial law, including property law, contracts, intellectual property law partnerships and companies. The last part of course concerns administrative aspects of conducting business activities including: registration in the National Court Register or in the Economic Activity Records; different forms of restrictions: concessions, regulated activities and permissions and finally basic concepts of labour law, competition law and tax law.

Bibliography:

Course results:
After completing his course the students will be able to understand and prepare basic contracts. He will distinguish between different forms partnerships and companies. He will be able to set up a business and find basic information about business units in the National Court Register. He will have basic notions about different forms of job contracts and taxation.

Grading criteria:
Multiple choice test

Detailed contents:
1. Introduction to jurisprudence. Basic concepts
2. Constitutional Law
3. Sources of Polish and European business law
4. Civil Law (1) – general provisions
5. Civil Law (2) – property law
6. Civil Law (3) – contracts
7. Civil Law (4) – intellectual property law
8. Partnerships
9. Companies
10. The National Court Register & the Economic Activity Records
11. Concessions, Regulated Activities and Permissions
12. Labour Law
13. Competition Law
14. Introduction to tax law
15. Test & Assessment
SYLLABUS

Course name: Computational fluid dynamics
Course name in other language: CFD
Short name: ANK348
Course number: ANK348
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: Exam
by semester: [ 30, 0, 15, 0, 0 ]

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1

Lotnictwo i Kosmonautyka: Aerospace Engineering
Study level: undergraduate, full time
Recommended semester: 7

Mechanika i Budowa Maszyn: Computer Aided Engineering
Study level: undergraduate, full time
Recommended semester: 6

Contents - short:
Knowledge about methods and tools of computational fluid dynamics

Bibliography:

Grading criteria:
2 tests on theoretical part, work and progress of each student are evaluated in the framework of the point system, individual semester project

Detailed contents:

Additional remarks (by course staff):
The laboratory groups can consist of at most 12 students
SYLLABUS

Course name: Energy Policy and Law
Course name in other language: Polityka energetyczna i prawo energetyczne
Short name: EPAL
Course number: ANK487
Course language: English
Responsible for the course: prof. dr hab. inż. Tadeusz Skoczkowski
ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 2, 0, 0, 0, 0 ]
Form of grading: Continous assesment
by semester: [ 30, 0, 0, 0, 0 ]
Field of Study: Energy Policy and Law
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1
Prerequisits:
Electric Power Systems (ANK381)

Contents - short:
To understand world’s and EU energy resources, supply and demands.
To understand the ongoing changes in global energy markets, including EU internal energy market.
To gain general knowledge on energy policy of the EU and Poland.
To understand the transformation to sustainable energy systems.
To learn the modern concept of energy security.
To understand fundamentals of electricity reform and competition in electricity markets.
To get familiar with main trends in energy research and promotion.
To gain in-depth knowledge on energy law in Poland.
To understand legal regulations concerning environmental impact of energy sector.
To understand legal status of distributed generation.

Bibliography:
Further Readings:
Selected readings from OECD/IEA and Energy Charter Secretariat websites (provided by lecturer).

Course results:
Understanding of the process of globalisation in the world’s energy market.
To get familiar with objectives of the energy policy of the European Commission.
Ability to understand business processes in energy market and market law regulations.
Ability to understand the EU energy law and environmental law influencing energy processes.
Ability to understand Polish energy law and main decrees related.
Ability to understand main research trends in the EU.
Ability to recognise benefits, driving forces and barriers to distributed generation.

Grading criteria:
Tests in lectures+final assessment.

Detailed contents:

SYLLABUS

Course name: Energy efficiency
Course name in other language: Efektywność energetyczna
Short name: ENEF
Course number: ANS500
Course language: English
Responsible for the course: prof. dr hab. inż. Tadeusz Skoczkowski

ECTS: 2
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
weekly: [ 1, 0, 1, 0, 0 ]
Form of grading: Continuous assessment
by semester: [ 15, 0, 15, 0, 0 ]

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1

Prerequisites:
Business Law (ANK371) , Economics (ANW112) , Electric Machines 1 (ANK333) , Electric Power Systems (ANK381) , Environment protection (ANW109)

Contents - short:
To gain general knowledge on energy efficiency policy in the EU and Poland.
To get familiar with variety of energy efficiency measures applied in industry.
To understand fundamentals of energy management systems and energy audits methodology.
To learn the objectives and methods of the Demand Side Management.
To get familiar with the protocol on energy measurement and verification, including statistical approach to measured data.
To understand basic economics of energy efficiency.

Bibliography:

Course results:
Understanding of objectives, advantages and barriers of implementation of energy efficiency policy in industry.
Being familiar with general methods of improving energy efficiency in industry.
Ability to understand and be able to select proper energy measure to be applied in industry.
Being familiar with fundamentals of standard energy management systems.
Understanding methodology and practical methods of measurement and verification of energy savings in industry.
Ability to assess economic advantages of typical energy efficiency measures and investments.
Ability to assess uncertainty of measurements and verification of energy savings.

Grading criteria:
Tests in lectures+final assessment.

Detailed contents:
Course name: Energy transport
Course name in other language: Transport energii
Short name: ENTRA
Course number: ANK415
Course language: English
Responsible for the course: prof. dr hab. inż. Jerzy Banaszek

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

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1

Contents - short:
Analysis of energy losses, based on the combination of the First and Second Laws of Thermodynamics, when applied to various thermodynamic processes occurring in heat machines. Fundamental concepts and theory of mass transfer phenomena and concurrent heat and mass transfer processes, their occurrence in nature and applications in technology.

Bibliography:

Course results:
After completing the course a student will be able to identify main sources of energy loss in various heat and mass transfer systems, and to perform an elementary quantitative analysis needed for the quality assessment of energy and mass transfer phenomena in various parts of power plant installations.

Grading criteria:
Two problem solution tests during the course (mid-term tests) and a theoretical test at a final exam. All tests must be passed and a final grade is an arithmetic mean of all tests evaluations.

Detailed contents:
Lectures: Fundamental mechanisms of energy transfer. Application of the First and Second Laws of Thermodynamics in the quality assessment of energy transfer phenomena – a review of irreversible processes. Examples of mass transfer in nature and technology. Fundamental concepts and transfer
mechanisms of a mixture component. Molecular diffusion and its one-dimensional practical models (plane wall and cylindrical geometry, transient mass diffusion, equimolar counter-diffusion, Stefan flow). Convective mass transfer - forced and natural convection, the boundary layer theory, mass convection empirical relations. Analogy of heat, mass and momentum transfer, Chilton-Colburn analogy and its practical application. Simultaneous heat and mass transfer - examples

Tutorials: Calculations of power losses in selected irreversible processes - such as fluid flow with friction, heat transfer, gas mixing, Joule’s effect and combustion occurring in pipes, valves, combustion chambers, heat pumps, internal combustion and turbojet engines. Computation of diffusive and convective mass transfer, using one-dimensional analytical models, empirical relationships and Chilton-Colburn analogy in various processes, such as the waste utilisation, steel carbonizing, humidification and drying of air and other media, NOx propagation in the atmosphere and thermal convection around a body of a complex geometry (calculation of convective heat transfer coefficient).

Additional remarks (by course staff):
Handouts will be provided
SYLLABUS

Course name: Engineering Project
Course name in other language: 
Short name: ENPROJ
Course number: ANK382
Course language: English
Responsible for the course: prof. dr hab. inż. Tadeusz Skoczkowski

ECTS: 3
Course level: Exam
Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 0, 0, 0, 4, 0 ]
by semester: [ 0, 0, 0, 60, 0 ]

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2
SYLLABUS

Course name: Finite element method 1
Course name in other language: Metoda elementów skończonych 1
Short name: FEM1
Course number: ANK342
Course language: English
Responsible for the course: dr inż. Grzegorz Krzesiński
ECTS: 4
Number of hours: [ Lc, T, Lb, P, S ]
Course level: basic
Form of grading: Continous assesment
weekly: [ 2, 0, 1, 0, 0 ]
by semester: [ 30, 0, 15, 0, 0 ]

Field of Study: Power Engineering
Field of Specialization: graduate studies, full time
Study level: Recommended semester: 1

Energetyka

Lotnictwo i Kosmonautyka

Mechanika i Budowa

Maszyn

Power Engineering
Aerospace Engineering
Computer Aided Engineering

graduate studies, full time
undergraduate, full time
undergraduate, full time

Prerequisits:
Mechanics of structures 1 (ANW117) , Mechanics of structures 3 (ANK428)

Contents - short:
The course supplies the basic knowledge and skills required for understanding FEM and simple practical applications of the method. It consists of the theoretical part (30 hours of the lectures) and the practical ones (15 hours of the finite element modelling using ANSYS program).

Bibliography:
Lecture notes
Saeed Moaveni: Finite Element Analysis. Theory and Application with ANSYS, Paerson Ed. 2003

Course results:
After completing the course the students will be able to build simple FE models and will understand the applications and limitations of the method in stress analysis.

Grading criteria:
Assesment based on 2 tests and the results of computer lab (the reports)
Detailed contents:


Laboratory: Introduction to practical problems of FE modeling in ANSYS, 2D and 3D linear stress analysis, analysis of a simple shell structure.
### SYLLABUS

**Course name:** Future Power Technologies  
**Course name in other language:** FPT  
**Short name:** FPT  
**Course number:** ANS535  
**Course language:** English  
**Responsible for the course:** prof. dr hab. inż. Andrzej Miller  
**ECTS:** 2

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<td>by semester:</td>
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**Field of Study:** Energetyka  
**Field of Specialization:** Power Engineering  
**Study level:** graduate studies, full time  
**Recommended semester:** 2

**Contents - short:** Review of future power technologies

**Course results:** Basic knowledge about possible ways of future development of power engineering

**Grading criteria:** Final test

**Detailed contents:** Advanced power engineering system for central and distributed generation and supply of energy. Ultra supercritical parameters for steam systems gas-steam sets, coal gasification, fluidized bed combustion, fuel cells, hybrid systems and others

**Additional remarks (by course staff):** All course info available on http://energetyka.itc.pw.edu.pl
Course name: Information Systems in Management
Course name in other language: ITSIM
Short name: ANS59
Course language: English
Responsible for the course: prof. dr hab. inż. Janusz Lewandowski
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: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 3

Contents - short:
Base knowledge of database management systems and SQL. Understanding structure of ERP systems and its role in improving the management processes

Bibliography:

Grading criteria: paper about one of ERP modules and final test

Detailed contents:
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
Course level: basic
Form of grading: Exam
Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 0, 0, 0, 6, 0 ]
by semester: [ 0, 0, 0, 90, 0 ]

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2

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

Field of Study: Energetyka
Field of Specialization: -
Study level: graduate studies, full time
Recommended semester: 3

Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: -
Study level: 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: Energetyka
Field of Specialization: -
Study level: graduate studies, full time
Recommended semester: 3

Field of Study: Lotnictwo i Kosmonautyka
Field of Specialization: -
Study level: graduate studies, full time
Recommended semester: 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: Mathematical Modelling and Process Identyfication
Course name in other language: Modelowanie matematyczne i identyfikacja procesów
Short name: MMPI
Course number: ANK486
Course language: English
Responsible for the course: prof. dr hab. inż. Janusz Lewandowski

ECTS: 4
Course level: intermediate
Form of grading: Continuous assesment

Number of hours: [ Lc, T, Lb, P, S ]
weekly: [ 2, 1, 0, 0, 0 ]
by semester: [ 30, 15, 0, 0, 0 ]

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1
SYLLABUS

Course name: Neural networks
Course name in other language: Sieci neuronowe
Short name: NNET
Course number: ANK385
Course language: English
Responsible for the course: dr inż. Cezary Rzymkowski

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: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2

Contents - short:
Artificial neural networks – theory and application in process modeling

Bibliography:
1. Masters T., “Neural Networks”
2. Pham D.T., Liu X.; Neural Networks for Identification, Prediction and Control, Springer Verlag, 1995

Course results:
Basic knowledge of process modeling and computer systems (applications)

Grading criteria:
Midterm and final exam. Final grade based on achieved number of points

Detailed contents:
Theoretical fundamentals of neural networks. Types and structures of ANN. Application of artificial neural networks in process modeling. Examples of NN modeling process in power installation – MPC type controllers with NN models, NN for sensor validation, forecasting using NN. Practical modeling using ANN. Advantages and constrains of NN application
SYLLABUS

Course name: Numerical methods in heat transfer
Course name in other language: Metyka numeryczna w wymianie cieplnej
Short name: NMHT
Course number: ANK347
Course language: English
Responsible for the course: prof. dr hab. inż. Jerzy Banaszek
ECTS: 3
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: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 1

Prerequisites:
Fluid mechanics 1 (ANW122), Heat transfer 1 (ANK423), Partial differential equations (ANK481)

Contents - short:
Fundamental knowledge of contemporary computer simulation techniques in fluid mechanics and heat transfer (such as control volume method and finite element method) and training in application of these methods to engineering problems (with the use of selected commercial codes, such as Ansys Fluent and/or Fidap)

Bibliography:
5. R.W. Lewis and

Course results:
After completing the course a student:
• will be able to understand underlying assumptions, basic methodology and limitations of all consecutive stages of computer modelling of a real engineering problem;
• will be familiarized with all details of FEM and CVFDM simulation of heat transfer and fluid flow problems, and, in particular, with major difficulties encounter in such modelling of both: a pure molecular diffusion (e.g. in composite materials) and convection (e.g. wiggles, cross-wind diffusion, numerical
dispersion), as well as with special techniques of numerical errors elimination or reduction (e.g. up-winding, staggered grid approach, un-equal order FEM, grid refinement);
• will be able to use and modify, for his/her particular engineering problem to be solved (e.g. through the User Defined Functions), commercial codes applied for both: grid generation and calculations;
• will be able to correctly interpret obtained numerical results, in particular, to distinguish between potential numerical inaccuracies an specific features of the analysed physics.

Grading criteria:
An assessment consists of two parts: (1) a final theoretical test of the knowledge acquired during lectures;
(2) a practical test in the lab.
A final grade comprises 60% of the theoretical test grade and 40% of the laboratory test evaluation.

Detailed contents:
Lecture:
1. From reality to its computer simulation - successive stages of a model development.
3. Methods of a geometrical domain discretization.
5. Solving steady-state and transient diffusion on control volume and finite element grids.
6. Special numerical techniques for convective-diffusive transport – upwind schemes in CVFDM and FEM.
8. Review of effective computational algorithms in CVFDM and FEM modelling of incompressible fluid convection.
10. Introduction to turbulence modelling.
11. Credibility of a computer simulation – verification and validation, examples of credibility assessment.

Computer Lab:
1. Introduction to ANSYS Gambit – step-by-step division of 2D complex domain into control-volumes, structural and non-structural grids, types of domain and boundary conditions, application of advanced functions in a local mesh refinement.
2. Introduction to ANSYS Fluent – mesh diagnostics, boundary and initial conditions, material properties, solver settings, graphical post processing, User Defined Files. 3. Examples of modelling with the code Fluent: 3D natural thermal and/or solutal convection, thermal radiation, convection in porous media, and/or heat transfer in a turbine blade.

Additional remarks (by course staff):
handouts will be provided.
# SYLLABUS

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

**Field of Study:** Energetyka  
**Field of Specialization:** Power Engineering  
**Study level:** graduate studies, full time  
**Recommended semester:** 1  

**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:
Peter O’Neil, Advanced Engineering Mathematics,  
Wadsworth Publishing Company, USA.

### 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 simple problems in PDE’s

### Detailed contents:
1. Fourier analysis  
   - the Fourier series of a function; applications to forced oscillation and resonance;  
   - the Fourier integral, sine and cosine integrals; Computer calculations of Fourier coefficients;  
   - 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 Mathlab for solving PDE’s and visualization of solutions.
## SYLLABUS

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<td>dr Piotr Lesiak</td>
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<td>by semester:</td>
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| Field of Study: | Energetyka |
| Field of Specialization: | Power Engineering |
| Study level: | graduate studies, full time |
| Recommended semester: | 2 |

### Contents - short:

The course contains basics of relativity and wave optics.

### 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: Project Management
Course name in other language: PROJMAN
Short name: ANK445
Course number: ANK445
Course language: English
Responsible for the course: dr inż. Wojciech Bujalski

ECTS: 2
Course level: basic
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: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 3
SYLLABUS

Course name: Statistical and Nonequilibrium Thermodynamics
Course name in other language: Termodynamika statystyczna i nierównowagowa
Short name: SANT
Course number: ANS599
Course language: English
Responsible for the course: prof. dr hab. inż. Piotr Furmański

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

Field of Study: Energetyka
Field of Specialization: Power Engineering
Study level: graduate studies, full time
Recommended semester: 2

Prerequisits:
Thermodynamics 1 (ANW116), Thermodynamics 3 (ANK413)

Contents - short:
Knowledge of link between microscopic, statistical phenomena and macroscopic behaviour of materials.
Knowledge of cross-effects and their applications

Bibliography:
1) T.L. Hill: “An Introduction to Statistical Thermodynamics”,
4) Materials for students placed on website

Course results:
After completing his course the students will be able to understand meaning of the macroscopic properties and specify processes occurring close and far from thermodynamic equilibrium.

Grading criteria:
solution of two complex problems in statistical and non-equilibrium thermodynamics

Detailed contents:
Lecture:
1. Fundamentals of kinetic theory of gases and transport theory.
2. Boltzmann equation.
3. Microstate and macrostate.
5. Statistical interpretation of thermodynamic functions.
7. Postulates of the linear non-equilibrium thermodynamics. Generalized forces and fluxes.

Tutorials:
1. Examples of electro-kinetic applications.
2. Examples of thermoelectric applications,
3. Examples of thermionic applications. and thermo-electromagnetic applications.