TRANS-NATIONAL EUROPEAN EVALUATION PROJECT

SOCRATES PROGRAMME

Faculty of Physics
Warsaw University

WYDZIAŁ FIZYKI

UNIWERSYTET WARSZAWSKI

European Network of Quality Assurance in Higher Education (ENQA)

SOCRATES Thematic Network in physics (EUPEN)

European Commission

Warszawa 2002

Motto:

A solid education in physics is the best conceivable preparation for a lifetime of rapid technological change that our young people face.

D. Goodstein,
California Institute of Technology, Pasadena, USA
APS News **9**, #6 (2000)

Introduction

The Polish community experienced an enormous loss of human potential, especially its highly educated part, during World War II . Therefore many years were devoted to its rebuilding. This was also the goal of the Warsaw University and its Faculty of Physics. Up to 1990 the general model for high education in sciences represented at the university was a five year programme for a Master degree. In other areas like technical or economical sciences a two level (Bachelor/Master) model was adopted parallel to the one-level Master studies. The situation where only a five year Master programme is available become inadequate for modern physics studies. We think, that the latter model is still the best for people planning a career in science or education up to the PhD level, but it can be too much time consuming and/or too difficult for students planning different careers. Therefore the state regulation allowing the Bachelor degree in sciences was in line with our needs. Owing to this regulation we can extend our offer for high school graduates on different levels. This leads to an important increase of the number of students – currently more than 300 students enter the first year.

The Faculty of Physics conducts the main teaching programme in Astronomy and Physics. Supplementary teaching activities are realized within the Faculty subunits:

- The Physics Teachers College
- The Post-graduate Studies (Ph.D. Studies)
- The Continuing Education Courses in Physics and Astronomy for Teachers

In this report only the main Physics teaching stream is considered, so the activities of the mentioned subunits are not taken into account.

From the scientific point of view the Faculty of Physics is divided as follows:

- Institute of Experimental Physics,
- Institute of Theoretical Physics,
- Astronomical Observatory,

- Institute of Geophysics,
- Chair of Mathematical Methods in Physics.

All these scientific units of the Faculty participate in the teaching programme.

In this report only the first three years of the main Physics teaching stream are considered (without Astronomy).

Part A: Context

1. Regulations and programme approval procedures

- The Faculty's Council Programme Committee establishes the frames of the programme after consultations with the Institutes and one Chair, and taking into account state regulations (*Ustawa z dnia 12 września 1990 r. o szkolnictwie wyższym*), like programme standards, published by the Ministry of National Education and Sport. These frames are finally approved by the Faculty's Council. Next, the Institutes and the Chair are asked to designate their representatives responsible for the realisation of the programme. However, the lecturers implement the programme frames in an individual way. They are obliged to apply to the dean for acceptance of changes in the frame programme in order to ensure better relations between different topics. These changes can be made, however, only after obtaining a favourable opinion from the Programme Committee.

- In principle all decisions regarding changes in the programme and the system of studies are left by the University authorities to the Faculty. In the case of the Faculty of Physics the Faculty Council approved a system which allows different ways of reaching different degrees (Bachelor, Master and PhD). The system is prepared in a transparent way easy to understand for the candidates for studies at the Faculty.

- Students at the Faculty of Physics can major in physics or astronomy. Various study programmes are offered in both major subjects.

  Programmes in physics are organized as follows:
  - Five or five and half years programme, depending on the specialization, leading to the Master degree,
  - Three year programme to the licentiate (Bachelor degree),
  - Two year supplementary programme for Bachelor degree holders leading to the Master degree.

  The Programme in astronomy lasts five years, leading to the Master degree.

  The post-graduate (Ph.D.) studies in physics and astronomy last 4 years.

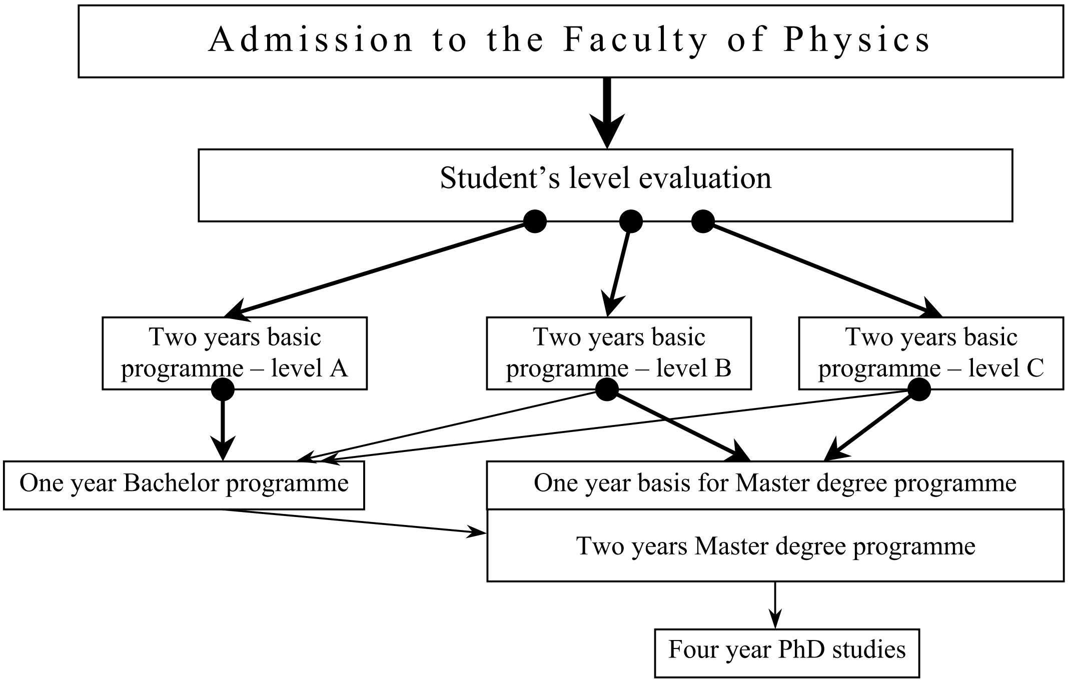
  Physics and astronomy curricula are organized as follows:

The first two years are common for all students (Bachelor and Master degree students of physics, and Master degree students of astronomy). Students can choose the level of the offered physics and mathematics courses (three levels), and, besides, during the second year they can choose courses from the proposed curriculum of general studies.

After the second year the students have to choose between the programme for the Master or Bachelor degree.

- **Bachelor degree** programme lasts two semesters and can be completed in three specializations: *computer methods in physics, environmental physics, material science and* optics. During the third year the students follow the courses according to the chosen specialization. After passing the required exams, submitting the Bachelor Thesis, and passing the final examination, they obtain the Bachelor (licentiate) degree in physics. A two year supplementary programme leads to the Master degree.

- During the third year of studies for the **Master degree** in physics and astronomy the students have a choice of courses from the proposed curriculum of general studies. The last period of studies for the Master degree in physics and astronomy lasts two or two and half years, and is devoted to specialization and preparation of the Master Thesis. The students have a choice from among sixteen specializations represented at the Faculty (experimental physics: biophysics, solid state physics, physics of the elementary particles and fundamental interactions, nuclear physics, computer physics, medical physics, environmental physics, nuclear methods in solid state physics, optics, Fourier optics and image processing, X-ray structural studies, and nuclear spectroscopy, theoretical physics, geophysics, astronomy, didactics and popularisation of physics). They are introduced to research work, attend specialized courses, and participate in seminars in research groups. After passing all the required exams, submitting the Thesis and passing the graduation examination, the students receive the degree of Master in physics or astronomy.



2. Academic staff

The academic staff is organized in scientific Institutes and one Chair according to scientific domains. Part of the teaching programme is strictly related to the scientific needs of the Faculty. Different parts of the programme are realized by specialists from the proper Institutes, e.g. Analysis and Algebra courses are taught by teachers from the Chair of Mathematical Methods in Physics, while Laboratories for students are handled by the staff of the Institute of Experimental Physics. However, since our graduates are later employed even in financial institutions like banks, they need some basic courses in areas which do not belong to the Faculty scientific scheme. Therefore we see a need to ask other Faculties of the University to appoint qualified lecturers as is the case with English teachers. In our opinion there is no need to have such specialist among the academic staff of the Faculty.

For specified posts in the academic staff the Faculty organizes competitions. Usually the winners come from our own staff (promotion) or former PhD students. The rules of evaluation of staff development are provided by the state authorities every four years. Such an evaluation has to be made for every person. There are also time limits for occupying a given post. This enhances the development of the staff.

The number of staff members strictly depends on the financial means provided by Ministry of National Education and Sport. In the last years the number of the staff stay constant. New people can only be employed if posts are evacuated by others. As it is seen, the plan is to keep the number of staff constant ensuring at the same time its highest possible level. However, this number is strongly limited by unknown government policy in the education area.

3. Student population

Each year the faculty has over 600 candidates, but about half of them resign before the final admittance date. Only about 50 have to pass the exam (see Admission rules). Candidates can apply to study in many places (universities or faculties) and later choose one the most suitable for them. Then the Department of Physics serves as a "safety place". The first year is started by about 200 students.

Admission rules. The winners of the central Physics, Mathematics, Chemistry, and Informatics Olympic contests, the finalists of such contests for secondary school students, and present year high school graduates with good average marks in physics and mathematics enjoy a free entry. A free entry is also granted to the candidates with international baccalaureate diplomas with appropriately high grades. The remaining candidates have to pass a written admission examination in physics and mathematics.

Since the high schools present different levels (there is no final high school state exam) we are obliged to check the students level before allowing them to enter a given level (see 4). Previously, we asked the candidates to make the test supplied by the faculty by themselves at home and on this basis make a self-evaluation. This system did not work so since the last two years it is the Faculty that makes the evaluation. The resulting spread of students in the three levels is as follows:

- A – 140 (elementary level)
- B – 40 (intermediary level)
- C – 20 (advanced level)

There are no part time students, but some students study simultaneously at other faculties.

Students per teacher ratio

- Lectures – all the students attending the given level (e.g. 210 for A, 90 for B+C – common lectures, but different exercises);
- Exercises – not more than 20 per teacher;

- Laboratories – no more than 8 per teacher.

The second year is entered by 40 % A and 60% B, C group. From among them 60% choose (or is obliged to pursue) the bachelor degree – mostly from the A group.

So far we have no information about the actual problems of unemployment among our graduates.

4. Programme scenario

There are very different levels of intake of students at the University. There are the so-called "mega" faculties with over thousand students and much smaller ones with a dozen or so.
The same holds for the total number of students. Physics Faculty with its 1000 students is among medium size faculties. This number of students is practically contained in the limit of the Faculty's capacity. The most severe limits relate to laboratories, without which no education in physics is possible and where there is no free space for extra classes.
The number of institutions that can employ physicists as physicists is very limited. There is practically no modern industry with specialized laboratories. Most factories operate as part of international consortia, which design their products and technology abroad. However, due to that our graduates have a good computer background they are employed to solve untypical problems and they find employment in small businesses and market related organizations (banks, insurance companies, consulting companies, etc.).

All our institutes are involved in the teaching programme:

- Institute of Experimental Physics: lectures in basic physics with experimental illustrations, exercises related to these lectures, laboratories, specialisation courses for Master degree (lectures, tutorials, laboratories).
- Institute of Theoretical Physics: lectures and exercises in Quantum Mechanics, Electrodynamics, Statistical physics, Mathematical methods in Physics, specialisation courses for Master degree (lectures, tutorials).
- Astronomical Observatory: lectures and exercises in astronomy.
- Institute of Geophysics: laboratory, specialisation courses for Master degree (lectures, tutorials).
- Chair of Mathematical Methods in Physics: fundamental lectures and exercises in Analysis and Algebra for B and C levels, specialisation courses for Master degree (lectures, tutorials).

The highly specialized **libraries**, with rich resources, serve both the students and the academic staff.

Laboratories for students of the Faculty of Physics include: Physics Laboratories for Beginners and Advanced Level, Electronics Laboratory, Demonstration Experiments for courses, Laboratory for Physics Teachers, Laboratory of physical methods in environmental studies.

The students have access to a well equipped **computer centre** of the Faculty of Physics with over 40 terminals connected to the Internet.

Part B: Competences and learning outcomes

1. Aims and outcomes

1.1 The aims and outcomes of the learning process are defined for each level of studies and each specialitzation. The expected competences vary accordingly:

a) Bachelor studies are to provide a basic knowledge of physics and some specialized knowledge related to the profile chosen by the student. In terms of primary skills, the students are trained to solve encountered problems by a scientific approach which basically involves three stages: formulation of the problem in the universal language of physics, seeking analogies to other physical problems and finding methods of solution. It is very important that the students develop skills related to the application of computers. They are taught computer programming, desktop publishing and internet techniques.

b) Master studies involve acquiring deepened knowledge of physics and mathematical methods of physics. The expected subject-related competences depend strongly on the chosen student's specialization. They are determined by the directors of different specializations and published at the Faculty. The general skills are analogous to those expected from the BSc students. In addition Master students have to be capable to conduct (supervised) scientific work, which requires a certain self-discipline, responsibility and criticism.

1.2 Required competences for each course are defined and published by the Faculty.

1.3 In order to meet the needs of students with different abilities and level of education obtained at the high school, the studies at our Faculty are divided into parallel paths A, B and C as described in part A. Additionally, many topics are taught in parallel courses with the use of a distinctly different methodology of teaching.

1.4 The programme of lectures is synchronized to ensure a proper level of student progress. The scope of the courses is constantly upgraded due to international contacts via visitor programmes. The internet plays a significant role, since it provides easily available information about universities in Poland and abroad. The competences of our students are verified through their participation in student exchange programmes and the success in the postgraduate studies.

2. Programme content (curriculum)

The present curriculum developed over a long period of time as a consequence of constant adjustments to the development of physics, techniques of teaching and finally, political changes in Poland. During the last decade we have noted great differences in education on the high school level. Accordingly, three streams of studies were created as described above. In response to the changes in technology and job market trends we have introduced new specializations of BSc studies: computer methods of physics, optics and material science and environmental physics.

3. Subject related competences

At the beginning of studies, the students acquire the necessary theoretical skills in order to be able to follow more advanced courses. They also learn elementary experimental physics and carry out simple projects in the primary and first level student laboratories. Thus the core programme consists of two blocks of subjects (experimental and theoretical), which are strictly complementary to each other.

Block of general physics

General physics is taught in two steps: two-years basic programme and specialistic courses lasting one year (see diagram 1, part A).

Two-years basic programme in physics

<u>Bachelor's level (level A)</u>

Teaching of physics at bachelor's level is realized in five courses (Introductory Physics I ... V). The general aim of these courses is to present physics in a very intuitive way, without resorting to advanced mathematical tools. The programme consists of basic items of:

- Classical mechanics (Newton's laws)
- Special relativity
- Electrodynamics (up to the Maxwell equations)
- Oscillations, resonances and waves
- Thermodynamics
- Introduction to quantum systems

The lectures are richly illustrated with demonstrations of physical effects, in order to work out a connection between the real world and the description of reality within physical models.

During the first semester the students of level A have 50% more hours of physics compared to the master course. This allows a more detailed explanation of problems and helps the students to reach the level of physics necessary for further studies.

Master's level (levels B and C)

These levels are more advanced than level A and the courses make more extensive use of mathematics. The programme is enriched by several aspects of physics like statistical description of (classical and quantum) many-body problems. Levels B and C share the same physics lectures, but the programme is differentiated at the level of physics classes, where C level students are guided through the solutions of more advanced problems.

Teaching of the basic techniques of measurements in physics complements the lectures and classes for all levels (A, B, C). This part of education consists of an introduction to the principles of measurements and data analysis, and laboratory classes. The laboratory classes start with an introduction to the basic techniques of measurements of electrical quantities (the use of voltmeters, ammeters and oscilloscopes, also digital). In the next year students realise and analyse about 20 experiments from different areas of mechanics, electricity, optics, thermodynamics and nuclear physics.

After the two-year block the students get acquainted with the principal physical processes and are prepared for the next part of studies. Depending on the level of their preparation, they follow the final year of the bachelor's course or enter the third year of preparations for the master studies.

Final year of bachelor's programme

This programme is obligatory for students of level A, except those having notes good enough to enter the Masters Programme. The students have the choice of several options:

- Computer methods of physics,
- Physics of environment
- Optics and material science

The programme is specific for each option, e.g. students selecting the last from the above mentioned options follow an introduction to the physics of the atom, compounds and condensed matter. During the last semester the students prepare the Bachelor Thesis under the supervision of a faculty teacher. Another teacher is later the referee of this work. The Bachelor's degree is granted after the final examination headed by the deputy dean of the faculty.

Third year Master's Programme

The third year of studies in the master programme concentrates around more advanced problems, which leads towards some aspects of contemporary physics research. Students are obliged to attend a number of lectures followed by examinations and physics laboratories. Attending the lectures and laboratories the student can accumulate a certain specified amount of points. The students, while selecting their lectures and laboratories have to obtain a minimum number of points determined by the Dean's programme committee. This system takes into account also the lectures and laboratories of the second year of studies (however, the choice of lectures during the second year is limited).

At the end of the third year students select the scientific groups within which they intend to prepare their Master's degree. As each group has its own requirements, so the students have to consider them when selecting their lectures in the third year. For example, theoretical groups do not require so much laboratory work but rather theoretical studies. For instance, quantum mechanics is obligatory for nuclear and particle physics, but not for geophysics students.

The lectures proposed for the third year studies cover a wide range of experimental topics:

- Introduction to particle and nuclear physics
- Introduction to optics and solid state physics
- X-rays and neutron diffraction
- Introduction to particle physics
- Geophysics
- Biophysics
- Astrophysics

Block of mathematics and theoretical physics

The block of theoretical subjects taught at the Faculty is divided into three sections:

1) Mathematics and Mathematical Methods in Physics (first and second year)
2) Theoretical Physics (second, third and fourth year)
3) Elective courses and seminars in theoretical physics (fourth and fifth year)

As mentioned above, students of our Faculty can chose between two distinct paths leading to the diploma.

- The Bachelor Studies, which lead to the BSc degree, last three years and have a somewhat technical or applied profile.

- Master Degree studies, where the last five or five and a half years, are designed for students who have a scientific or an academic career in mind or whish to study physics more exhaustively.

Master studies can be again roughly divided into experimental and theoretical lines. This diversity in education programmes induces a certain elasticity in the strategy of how the theoretical subjects are taught.

Although the core curriculum for all students during the first two years is basically identical, they can choose from different variants of the same course, typically labelled as A,B and C. The Faculty assists the students in making this choice by:

a) Providing a qualification tests for the first-year students
b) Publishing a detailed synopsis of all courses including the required prerequisites.
c) Publishing requirements for each specialization
d) Publishing examples of internally consistent flows of studies for specific specializations.

The purpose of this block is threefold.

First, the students are to gain basic operational skills in mathematics on the level necessary to follow courses in physics. They learn standard techniques of solving most commonly encountered physical problems. Although only highly specialized branches of mathematics can be covered by this block, a constant effort is made to adjust the curriculum of mathematical and theoretical subjects to the whole programme.

The second aim of this block is to develop the ability of describing physical problems in mathematical terms. The students have to understand the meaning and the relationship between the theoretical model and physical reality. They have to be able to asses the quality and limitations of a given model.

Finally, by analysing many examples, the students learn the most fundamental rules of formulating laws of physics.

The quality of the theoretical programme is maintained by:

a) Taking into account students' evaluations of the teaching process,
b) Consulting the curricula of the courses with other teachers,
c) Supervision by the Programme Committee,
d) Student progress assessment by the dean.

The students gain their theoretical skills by attending lectures and by solving problems, both under supervision and at home. The midterms and exams require mostly solving problems.

Mathematics and Mathematical Methods in Physics

a) **Mathematical Analysis and Algebra**

The basic course of mathematics includes three semesters of mathematical analysis (first and second year), and two semesters of algebra (first year). The BSc students are encouraged to take the block of lectures called Mathematics A, which incorporates both mathematical analysis and algebra and is usually taught by the same teacher as a single course. This is a basic training in mathematics, providing students with operational knowledge of mathematical techniques required in further studies on the BSc level.

The main goal of this course is to develop practical skills in solving simple problems of calculus of functions of one and several variables, solving algebraic equations and systems of linear equations in the real and complex domains. The students who accomplish this course should also understand the notion of vector space and be able to perform operations on vectors. They acquire an elementary knowledge of analytic geometry and learn basic facts regarding analytic functions of complex variables.

Most MSc students usually choose the courses Mathematical Analysis B and Algebra B which put emphasis on the intuitive and qualitative understanding of mathematical ideas and provide them with the skills of solving typical physical problems with mathematical tools.

Mathematical Analysis B aims at teaching the student classical techniques of calculus and leads him to the ability of unaided solving of typical problems encountered in practice of a physicists (investigating functions of one and several variables, analyzing convergence of sequences and series, both numerical and functional, computing simple integrals, solving differential equations, etc). Stress is laid on discussing and explaining the basic notions, illustrating the uses and interpretations of fundamental theorems (examples and counterexamples) rather than their actual proving. The necessary steps for developing mathematical intuition, e.g. by investigating solutions by qualitative methods, are provided during the course.

Algebra B covers in detail complex numbers and solving algebraic equations. It is also strongly focused on linear algebraic topics such as vector spaces, linear mappings and operators, eigenvalues and eigenvectors and elements of quadric surfaces.

Finally Mathematical Analysis C and Algebra C are designed for students who want to study mathematical and theoretical physics, although they are of course open to all students.

The aim of these courses is to extend slightly the list of topics taught in Analysis B and Algebra B, but especially to deepen those topics by a more complete treatment. Stress is laid here on the understanding of the role and interdependence of the used notions. Students, who have a deep interest in mathematics and the ability for independent study very often choose these courses.

In general, the objective of all these courses is to ensure that the student becomes familiar with mathematical approach to solving physical problems. He should gain an understanding for general rules, which stem from basic concepts and unified methods of mathematics and should be able to use those rules in particular applications.
The programmes of these lectures are constantly updated to ensure that they are in as close a correspondence with physical subjects as possible.

b) Mathematical Methods in Physics

This is the last course of mathematics taught in the fourth semester of the main core of the physics programme. It is again divided into two paths. Version A of this course is devoted to the group theory. It includes both the theory of discrete and continuous groups and the theory of representations. It is designed for the students whose future work will be connected with atomic and molecular physics or elementary particle physics. The objective of the parallel course called Mathematical Methods in Physics B is to provide the students with the knowledge of most frequently encountered special functions, which appear in the context of solving partial differential equations and second order linear equations of mathematical physics. This material is useful for the students who want to specialize in theoretical physics or mathematical physics.

Theoretical Physics

a) Classical Mechanics

Classical mechanics is taught in two courses, which are quite different as regards their purpose. Modern Theoretical Mechanics is intended to give the students the most basic skills in solving problems in mechanics as they arise in modern physics. Therefore it is less concerned with the mathematical derivations but mostly conveys basic ideas such as principles of relativity, motion of rigid bodies, some topics of analytic mechanics and relativity. The students become familiar with the terms, which they may encounter the popular scientific papers such as deterministic chaos. This course is preferred by BSc students and those, who are oriented towards experimental specializations.

The course called Classical Mechanics concentrates on the analytic aspects of mechanics, variational principle and the role of symmetries. It gives a good background for further theoretical studies of quantum mechanics and electromagnetism.

b) Quantum Mechanics

The basic course of Quantum Mechanics is taught in the fifth semester. It is a standard course which includes the basic notions of quantum mechanics such as wave function, Schrödinger equation, collision theory, symmetries, spin, perturbation calculus. The objective of this course is to prepare students for future lectures, which are based on the use of quantum mechanics.

A more phenomenological version of this subject is called Quantum Physics and is addressed to less theory oriented students. The aim of this course is to convey the basic principles of quantum mechanics with a minimal use of mathematics.

Students who chose specialization of theoretical physics have to take the advanced quantum mechanics course called Quantum Mechanics II. This course is delivered in two versions:

Version A concentrating on quantum relativistic field theory and addressed to students who are interested in elementary particle and relativistic physics,

Version B called Quantum Mechanics IIB giving quantum mechanical description of many-body systems ranging from solid state to nuclear matter.

The latter version is designed to provide tools for solving theoretical problems concerning quantum statistical theory.

c) Electrodynamics

MSc students take electrodynamics in the sixth semester. The course comes in two versions:

Electrodynamics of continuous media is devoted to the description of electromagnetic fields in the presence of materials such as dielectrics, magnetics and conductors. The aim of this course is to give the understanding of mutual interaction between systems with many degrees of freedom such as electromagnetic field and matter.

The parallel course Electrodynamics with elements of field theory is mostly devoted to the problem of the electromagnetic field propagation in vacuum and relativity theory. Emphasis is laid on teaching the students formal methods of classical field theory including such topics as variational formulation, role of symmetries and the covariant form of field equations.

d) Statistical Physics

The theoretical course of Statistical Physics I (seventh semester) is addressed to those MSc students whose further specialization requires familiarity with basic laws of thermodynamics and its statistical foundation. The course is mostly concerned with classical systems giving basic information about the probability theory and the notion of statistical ensembles. It further introduces microscopic models of phase transitions in various systems. It is required that students who want to take this course should first take the course in Thermodynamics or Phenomenological Thermodynamics**,** which are given in the third year.

Detailed descriptions of the courses are given in the appendix.

4. Generic Competences

The methods of teaching and the curriculum are organized so as to allow achieving the highest possible level of realisation of generic competences. Students are encouraged to independent studies. They take part in student seminars during which they learn the art of making presentations in a discipline not necessarily related to their specialization. Students of higher years participate in scientific projects conducted in the laboratories at the Faculty. During the meetings with prospective employers and "head hunters", which are regularly organized by the Faculty, they can learn about the requirements and expectations of the job market.

5. Teaching/learning methods and strategies.

The dominant teaching method during the first two years of studies is based on lectures and problem solving (so-called "exercises") in small groups. A typical size of such a group varies from 10 to 20 students. The small groups allow assessing the effectiveness of teaching by means of standard tests (homework, midterm exams) as well as direct interaction between instructors and students. The individual project work in the laboratory becomes important at higher years of education. The table below illustrates the proportions of typical teaching methods, in terms of time spent by students at the Faculty.

Teaching/learning methods of the programme, proportionally

	1. Year	2. Year	3. Year	4. Year (only vet.)	5. Year (only vet.)
Lectures	55%	40%	37%		
Small group teaching	40%	55%	29%		
Seminars			10%		
Coursework					
Projects					
Laboratory experiments	5%	5%	24%		
Trainee position					
Other					
In total	100 %	100 %	100 %	100 %	100 %

Students can modify the planning of the teaching and learning strategies by making suggestions to the instructors in the course of the semester. They also have representatives in the Programme Committee, which is responsible for education at the Faculty. This committee seriously takes the opinions of individual students expressed in the student's evaluations of lectures at the end of each semester into account.

6. Assessment

The assessment methods are designed to control the progress of learning by students according to the specific subjects and expected outcomes. Although the majority of courses end up with final examination, in many cases the assessed coursework is considered to be an adequate method of assessment. The table below presents typical proportions of assessment methods for a standard path in the MSc programme.

Assessment methods

Assessment Method	1. Year	2. Year	3. Year	4. Year (only vet.)	5. Year (only vet.)
Written examination	33%	22%	26%		
Assessed coursework	25%	8%	26%		
Laboratory experiment write-ups		40%	22%		
Essays					
Oral examination	42%	30%	26%		
Coursework reports					
Project reports					
Presentation					
In total	100%	100%	100%	100%	100%

Part C: Quality Assurance Mechanisms

Quality assurance is realized on two levels, namely external and internal. The external one is connected with an "accreditation" given by the University Accreditation Commission, member of the Network of Central and Eastern European Quality Assurance Agencies in Higher Education (http://main.amu.edu.pl/~ects/uka/uka-br.html). The Faculty of Physics of the Warsaw University received accreditation for five years. This means that every five years the Faculty has to pass an evaluation procedure in which the following standards are checked*:

a. Compatibility of classes (lectures, seminars, discussion groups, lab classes, etc.) with the specialization and publications of academic teachers teaching those classes who are full-time employees of the school.

b. Number of professors participating in the realization of the curriculum.

c. The number of students per one senior scholar teaching in the given department who is a full-time employee of the school applying for accreditation. The acceptable ratio will be set by the expert group.

d. Compatibility of the curriculum offered in the course of studies in this area and level of studies with the type of knowledge required for compatibility with European standards for this type of education.

e. Knowledge by the organizational unit of the school which offers education in a given area of the profile of the graduate.

f. System of gathering student opinions about the classes offered.

g. Facilities used for educational purposes, especially:
   - Accessibility of reading material recommended for students at the school's library.
   - Modern techniques of instruction and appropriate equipment of laboratories and other facilities for the given number of students.

h. Documented co-operation with significant scientific or scholarly centers, which offer education in analogous areas of studies, including - in the case of foreign schools - exchange of teachers and students.

Besides the Ministry of National Education and Sport publishes programme minima (see e.g. http://www.men.waw.pl/prawo/rozp_170/rozp_170.htm) for the given areas.

The internal quality assurance mechanisms are established to fulfil the goals of the accreditation procedure and programme minima.

First of all, the lectures are given and organized by a high level staff (Full or Associate professors). They supervise the staff of assistants for exercises and for experiments (during lectures illustrative experiments are presented).

After each "course" – end of semester – there is a students' poll on organization of the lecture and its quality (the set of questionnaires is in the Annex). The vice-dean for student affairs as well as the vice-directors of institutes responsible for teaching take into account the results of the poll for future lecture organization and staff evaluation.

There is also a feedback for the committee from staff the supervising the Bachelor and Master theses concerning the background student's education and demand for specific subjects, which have to be taken into account in the programme of the first stage of education. We also gather opinions from supervisors of our students taking part in the Erasmus-Socrates exchange program. This gives us a comparison of the level of our students to the level in other European universities.

The Committee also tries to take into account labour market demands, but not through any systematic studies (opinions from professional organizations). One example is the introduction of a specific "computer" course, namely "Introduction to data bases technology" for Bachelor studies in computer physics.

The Student's Council of the Faculty of Physics has made its own poll among students, concerning the organization of studies (Student's Council opinion as well as recent poll results are included in the Annex). The results are presented at the meeting of the Faculty Council and are taken into account in establishing the Faculty's policy.

Basically, quality assurance lies in hands of the Dean and the Program Committee headed by the vice-Dean for student affairs.

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* the following list is taken from official page of the Accreditation Commission

Part D: Reflection on the criteria

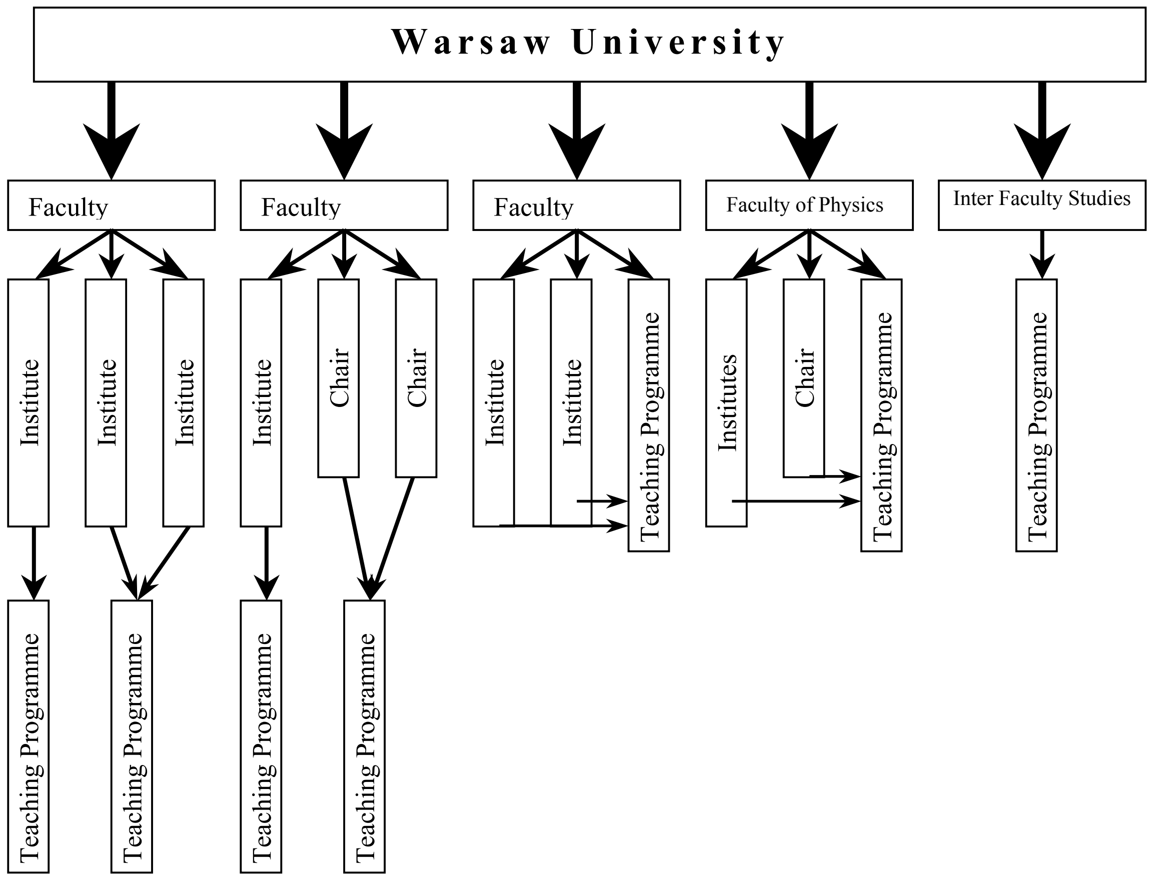
In our opinion the criteria for competences and learning outcome are understandable and clearly formulated. As regards of quality assurance, however, it may be difficult to receive any information from former students. So far except of those who decided to stay in science, information from other graduates or their employers are scarce.

Annex A - Data tables: context

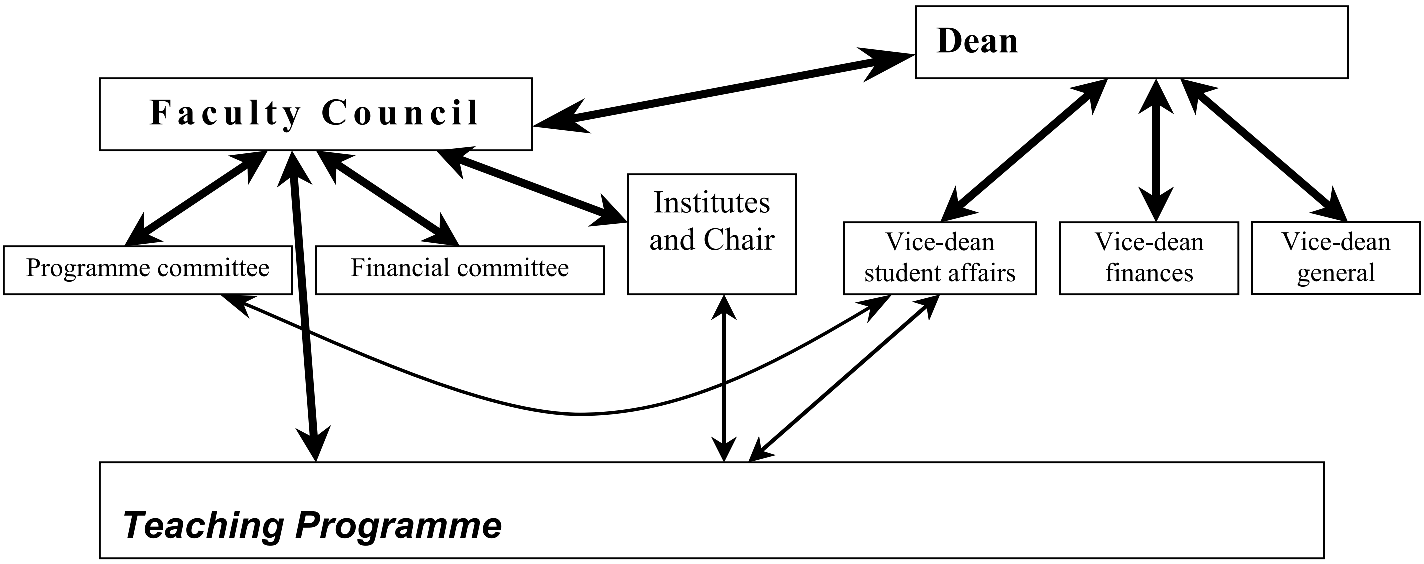
1. Details of the Programme

Name of the University (in English)	Warsaw University
Name of the University (in national language)	Uniwersytet Warszawski
Name of the Faculty responsible for the programme (in English)	Faculty of Physics
Name of the Faculty responsible for the programme (in national language)	Wydział Fizyki
Address	ul. Hoża 69, 00-681 Warszawa, POLAND
Name of the programme	Physics studies
Telephone	(+4822) 55 32 159
Fax	(+4822) 625 23 36
Title and name of the head of the programme	Dean of Faculty, Dr.hab. Jan Bartelski Prof.UW
Website	www.fuw.edu.pl

1.2 Relation of the programme to the university structure



1.3 Internal administrative structure of the programme



1.4 Responsibilities of the:

- Dean
  1. The Dean is the head of the Faculty and represents it outside.
     The Dean is the supervisor of all employees and students.
  2. The Dean makes decisions concerning the functioning of the Faculty that are not restricted to other University bodies or administration.
  3. The Dean also:
     - Supervises the activities of the faculty units;
     - Controls observation of law and safety in the faculty area;
     - Makes decisions regarding other problems as determined by law and in the university charter.

- Faculty Council
  The competences of the Faculty Council encompass:
  1. Establishing general lines of Faculty activities;
  2. Affirmation, after consultations with Student's Council, the teaching programs and plans of studies;
  3. Acceptance of the Faculty's material and financial plans;
  4. Assessment of the Dean's activity and approval of the Dean's annual report regarding activity of the Faculty;

5. Undertaking resolutions concerning other matters determined by the law and university charter

- Faculty Council's Committees

  The rules are determined by the Faculty of Physics regulation (§7). The committee is appointed by the Council and chaired by the Dean or vice Dean.

1.5 Dean and Vice-Deans are elected for a three year term. For the same term are also elected the directors and vice-directors of the Institutes by the Scientific Councils of Institutes.

1.6 Information about programme

Total number of academic years	3
Number of credits / annual number of lectures per year*	60 ECTS
Compulsory percentage of the total number of credits	80%
Number of electives (%)	20%
Mandatory courses under professional regulations	60%
Year of approval of the programme	1995
University / Faculty ownership (Public / private)	Public
European directives affecting the programme	
Other regulations	

*Consider ECTS or specify the conversion rule

2. Information on students at programme level

2.1 Intake of students

Year	Applicants	Admitted Male/Female/Foreign students	Entry requirements
2000-2001	557	200 143/57/1	
2001-2002	498	213 155/58/1	
2002-2003	628	232 173/59/2	

2.2 Student flow

Of the students whose admission year was 1999 how many were at present in 2001 (we consider only those who make Bachelor degree)

First year 1999	115
Second year 2000	45
Third year 2001	15
How many have graduated	2
How many have dropped out	31
How many are not in any identifiable year (For those students who cannot be placed in one specific academic year)	

2.3 Graduation

In the prescribed time for student graduation is N years, how many have completed in the prescribed time, how many within N+1 (within one year after prescribed time)

% Graduation in N	4%	
% Graduation in N+1 year	2%	
% Graduation in N+2 years	8%	
% Drop-out	In the first year	total
	26%	30%

2.4 Information on students at an institutional level

Evolution 2001	University
Students enrolled	53148
Intake students	14736

3. Information on staff

Number of academic staff in number of persons and full-time equivalents, 2001 attached to the programme

	Number of persons	Full-time equivalents
Full professors	10	4.3
Associate professors	25	11.0
Assistant professors*	31	20
Research assistants	10	2.4
Teaching assistants	2	1
PhDs.	78	
Other categories		
Academic staff in total	78	39

* *In our system there are two types of assistant professors position: first for PhD holders for 11 years, second for PhD and "habilitation" holder unlimited in time.*

Number of support staff to the programme and the academic staff in number of persons and full-time equivalents

	Number of persons	Full-time equivalents
Technical and Administrative staff	32	31

Annex B – Programme

Part I: Mathematics and Theoretical Physics

Course: **101A Mathematics A I**	
Lecturer: **prof. dr hab. Witold Bardyszewski**	
Semester: **winter**	*Lecture hours per week:* **6** *Class hours per week:* **6**
Code: **11.101101A**	*Credits:* **13**

Syllabus:

1. Scalars and vectors.
   - algebraic properties
   - dot product and norm
   - cross and mixed products
2. Differential calculus of functions of one variable
   - derivatives and rules of differentiation
   - indefinite integrals
   - definite integral and its applications
3. Sets and mappings
   - elements of mathematical logic
   - natural numbers and induction
   - mappings
   - denumerable sets
4. Complex numbers and elementary functions
   - exponential and log functions
   - trigonometric and hyperbolic functions
   - geometric representation of complex numbers
   - roots of complex polynomials
5. Systems of linear equations and matrices
   - determinants
   - Cramer's rule
6. Limits and continuity
   - sequences of numbers
   - continuous functions
   - functional series
7. Differentiation and integration
   - Mean values theorems
   - Taylor's formula
   - Riemann's integral
   - improper integrals and integrals with parameters

Literature:

1. W. Leksiński, I. Nabiałek, W. Żakowski, *Matematyka.*
2. M. Grabowski, *Analiza matematyczna.*

Prerequisites: Secondary school mathematics.

Examination: Homework, colloquia, written examination.

***

Course: **101B Mathematical analysis B I**	
Lecturer: **dr hab. Aleksander Strasburger**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.101101B**	*Credits:* **9**

Syllabus:.

This first semester part of the three semester course belonging to the main stream of the study finishing with the MSc. degree aims at providing the student with the classical tools of calculus thus leading him to gain the ability of unaided solving of typical problems encountered in practice of a physicists (investigating functions of one and several variables, analysing convergence of sequences and series, both numerical and functional, computing simple integrals, solving differential equations etc) and a very important ability of formulating physical, and generally scientific issues in mathematical terms.

The necessary steps for developing mathematical intuition, e.g. by means of investigating solutions by qualitative methods, are provided along the course.

The stress is laid on discussing and explaining the basic notions, illustrating the uses and interpretations of fundamental theorems (examples and counterexamples) rather then on their actual proving.

It is not assumed on the part of the student, that he has done advanced level of maths and physics at school. However, it is assumed that the student is acquainted with elementary functions (polynomials, trigonometric and exponential functions, logarithms) and has acquired a certain experience in formulating and understanding abstract notions and logical inference.

The scope of the course can be described as a slightly extended (e.g. with elements of differential equations) programme of the advanced level of mathematics at the high school (profiled mathematical - physical classes).

The material covered is absolutely necessary for successful completing the next semesters of the course.

Literature:

1. F. Leja, *Rachunek różniczkowy i całkowy*, PWN, Warszawa 1979 (i inne lata).
2. K. Kuratowski, *Rachunek różniczkowy i całkowy*, PWN, Warszawa, (wiele wydań).
3. W. Rudin, *Podstawy analizy matematycznej*, PWN, Warszawa, (wiele wydań).
4. K. Maurin, *Analiza cz.1 - Elementy*, PWN, Warszawa, (wiele wydań).
5. W.I. Arnold, *Równania różniczkowe zwyczajne*, PWN, Warszawa, 1975.
6. A. Sołtysiak, *Analiza matematyczna*, Cz. I i II, Wydawnictwo Naukowe UAM, Poznań, 1995.
7. R. Ingarden, L. Górniewicz, *Analiza matematyczna dla fizyków* , PWN, Warszawa, 1981.
8. K. Kuratowski, *Wstęp do teorii mnogości i topologii*, PWN, Warszawa, (wiele wydań).
9. W. Kleiner, *Analiza matematyczna*, (2 tomy), PWN, Warszawa, 1986-92.
10. Th. Bröcker, *Analysis I, II* (2 Auflage), Spektrum Akademischer Verlag, Heidelberg, 1995.
11. R. Strichartz, The Way of Analysis, Jones and Bartlett, Boston -London, 1995.

Prerequisites:

Examination: Pass-grade of class exercises, oral and written examination.

***

Course: **101C Mathematical analysis C I**	
Lecturer: **prof. dr hab. Stanisław Woronowicz**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.101101C**	*Credits:* **9**

The course is directed to those students that have predestination to abstract thinking and intend in the future to study theoretical physics in a more serious way.

Syllabus:

1. Theory of real numbers. Axiomatic approach. Examples of argumentation where Archimedes axiom and continuity axiom are used. Bounded sets and their extremes.
2. Elements of topology: Metric spaces. Examples. Open balls. Neighbourhoods. Open subsets of a metric space. The characteristic properties of the class of all open sets. Closed subsets of a metric space. Examples. The characteristic properties of the class of all closed sets. Limits of sequences of points of a metric space. Uniqueness of the limit. The limit of a sequence of points of a closed set belongs to the set. Sequences with the Cauchy property. Complete metric spaces.
3. Topology of real line **R**: Intervals in **R**. Open and closed sets in **R**. Bounded increasing (decreasing) sequences of real numbers and their limits. Three sequences theorem. Completeness of **R**. Examples of complete spaces.
4. Topology (continuation): Continuity of a mapping in a point. Definition and characteristic properties. Continuous mappings. Examples. Composition of continuous mappings. Cartesian product of metric spaces. Subspaces of metric spaces. Continuity of the embedding. Cartesian product of continuous mapping. Continuity of arithmetic operations. The algebra of continuous functions. Sequential definition of compact spaces and compact sets. Properties of compact sets. Cartesian product of compact spaces. Open coverings of metric spaces and their compactness. Properties of continuous maps defined on compact spaces. Uniformly continuous mappings. Compact subsets of **R** and $\mathbf{R}^N$. Connected sets in **R**. Connected sets and continuous maps. Darboux property of continuous functions.
5. Differential calculus of functions of one variable: The basic idea of differential calculus. Tangent functions of order *n*. Definition of the derivative. The derivative of the sum, product and quotient of differentiable functions. The derivative of the sum, product and quotient of differentiable functions. The derivative of polynomials and rational functions. The derivative of compositions of differentiable functions. Rolle theorem. Formulae of Lagrange and Cauchy. The derivative of the inverse function. Taylor formula and its applications. Extremes of differential functions. Rules of de l'Hospital. Convex functions and their properties. Examples.
6. Rieman integral: Directed sets and generalised sequences (nets). Definition of the Rieman integral. Examples. Integrability of a continuous function over a compact interval. Mean value theorem for integral calculus. Basic theorem coupling differential and integral calculus. Integration by parts and substitution.
7. Elementary functions: Logarithm. Definition and properties. Exponential function and its properties. Number *e*. Examples of sequences with limits expressed in terms containing number *e*. Taylor formula for exponential function. Convexity of exponential function and related inequalities. Series with positive entries and criterions of convergence. Series with

complex entries. Convergent and absolutely convergent series. Addition and multiplication of series. Exponential function of complex variable. Definition and properties. Trigonometric functions. Definition and properties. Derivatives of trigonometric functions. Number $\tilde{\pi}$. Definition. Formula $\varepsilon^{2\pi\iota}=1$. Computation of $\tilde{\pi}$. Geometrical interpretation of trigonometric functions. Inverse trigonometric functions. Definitions and derivatives. Techniques of integration, in particular integration of rational functions, Euler substitutions and trigonometric substitutions.

Literature:

1. Lecture notes
2. L. Schwartz, *Kurs analizy matematycznej.*
3. W. Rudin, *Podstawy analizy matematycznej.*
4. K. Maurin, *Analiza* cz.1- *Elementy.*
5. W. I. Arnold, *Równania różniczkowe zwyczajne.*
6. K. Kuratowski, *Wstęp do teorii mnogości i topologii.*

Prerequisites:

Examination: Pass-grade of class exercises, oral and written examination.

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Course: **103B Algebra and geometry B**	
Lecturer: **dr hab. Piotr Podleś**	
Semester: **winter and summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **11.101103B**	*Credits:* **9**

Syllabus:

1. Complex numbers: basic properties, geometrical interpretation, de Moivre's formula, n-th roots of complex numbers, cubic equations, the fundamental theorem of algebra
2. Vector spaces: systems of linear equations, subspaces, generators, linear independence, basis and dimension, the sum and intersection of subspaces
3. Linear mappings: matrices, kernel and image of a linear mapping, isomorphisms, the matrix associated with a linear map, rank of a matrix
4. Determinants: definition, the Laplace expansion, properties, Cramer's formula, permutations, Cauchy Theorem, inverse of a matrix
5. Linear operators: eigenvalues and eigenvectors, characteristic polynomial, Cayley-Hamilton Theorem, decomposition into characteristic subspaces, diagonalizability, functions of linear operators, projections
6. Quadratic forms: the Lagrange method of diagonalization, Sylvester Theorem, finding of the signature, Gram-Schmidt orthogonalization
7. Inner product: properties, orthonormal bases, orthogonal complement, orthogonal projection, distance, selfadjoint and unitary operators, diagonalization of quadratic form in an orthonormal basis, quadric surfaces

Literature:

1. P. Podleś, Algebra (lecture notes avaliable in the Faculty library).
2. S. Zakrzewski, *Algebra i geometria*
3. A. Białynicki-Birula, *Algebra liniowa z geometrią*
4. J. Komorowski, *Od liczb zespolonych do tensorów, spinorów...*

Prerequisites:
Examination: Class exercises are passed on the basis of colloquia and student's activity, written and oral examination.

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Course: **103C Algebra and geometry C**	
Lecturer: **prof. dr hab. Kazimierz Napiórkowski**	
Semester: **winter and summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **11.101103C**	*Credits:* **9**

Syllabus:

1. Complex numbers, fields, polynomials. Cubic equations, the fundamental theorem of algebra and its consequences.
2. Permutations and groups.
3. Vector spaces.
4. Linear operators, systems of linear equations.
5. The conjugate space, dual pairs.
6. Multilinear mappings, determinant.
7. Trace, determinant and characteristic polynomial of a linear operator. Eigenvectors and eigenvalues, Jordan bases.
8. Quadratic forms. Invariants and diagonalization.
9. Euclidean and unitary spaces. Hermitian, unitary and normal operators.
10. Affine and Euclidean geometry. Linear and quadratic submanifolds.

Remark: The main feature of Algebra C is not a wider list of subjects in comparison to Algebra B, but a deeper and more complete treatment. The stress is put on the understanding of the role and mutual dependence of used notions.

Literature:

S. Zakrzewski, *Algebra i geometria,* Z. G. Uniwersytetu Warszawskiego, 1994.

Supplementary literature:

1. A.I. Kostrykin, J. I. Manin, *Algebra liniowa i geometria* .
2. A.I. Kostrykin, *Wstęp do algebry.*
3. P. Urbański, *Wykład zalgebry dla fizyków,* Z. G. Uniwersytetu Warszawskiego, 1997.
4. J. Komorowski, *Od liczb zespolonych do tensorów, spinorów, algebr Liego i kwadryk.*
5. S. Lang, *Algebra.*
6. A.I. Kostrykin (red.), *Zbór zadań z algebry*.
7. M. Kordos, *Wykłady z historii matematyki.*

Prerequisites:

Examination: Pass of class exercises, oral and written examination.

Course: **105A Mathematics A II**	
Lecturer: **prof. dr hab. Witold Bardyszewski**	
Semester: **summer**	*Lecture hours per week:* **6** *Class hours per week:* **6**
Code: **11.102105A**	*Credits:* **15**

Syllabus:

1. Vector spaces
   - basis and dimensions
   - linear transformations
   - eigenvalues and eigenvectors
2. Ordinary differential equation
   - integration of ODE's of first order
   - linear equations of the second order
   - systems of linear equations with constant coefficients
3. Differential calculus in vector space
   - continuity of functions of n variables
   - partial derivatives and differentiability
   - extrema of functions of n variables
   - inverse mapping and implicit functions
4. Analytic geometry
   - parametric equations of curves and surfaces
   - manifolds of rank 2
5. Fourier analysis
   - Fourier series and Fourier integral
   - Fourier's theorem

Literature:

1. G.M. Fichtencholz *Rachunek Różniczkowy i Całkowy*
2. A. Mostowski, M. Stark *Elementy Algebry Wyższej*
3. A. Mostowski, M. Stark *Algebra liniowa*

Prerequisites: Mathematics IA.

Examination: Homework, colloquia, written examination.

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Course: **105B Mathematical analysis B II**	
Lecturer: **dr hab. Aleksander Strasburger**	
Semester: **summer**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.102105B**	*Credits:* **10**

Syllabus:
Many variable functions.

Literature:

1. F. Leja - *Rachunek różniczkowy i całkowy*, PWN, Warszawa, 1979 (i inne lata).

Suplementary literature:

1. K. Kuratowski, *Rachunek różniczkowy i całkowy*, PWN, Warszawa, (wiele wydań).
2. W. Rudin, *Podstawy analizy matematycznej*, PWN, Warszawa, (wiele wydań).
3. K. Maurin, *Analiza cz.1 - Elementy*, PWN, Warszawa, (wiele wydań).
4. W.I. Arnold, *Równania różniczkowe zwyczajne*, PWN, Warszawa, 1975.
5. A. Sołtysiak, *Analiza matematyczna*, Cz. I i II, Wydawnictwo Naukowe UAM, Poznań, 1995.
6. R. Ingarden, L. Górniewicz, *Analiza matematyczna dla fizyków* , PWN, Warszawa, 1981.
7. K. Kuratowski, *Wstęp do teorii mnogości i topologii*, PWN, Warszawa, (wiele wydań).
8. W. Kleiner, *Analiza matematyczna*, (2 tomy), PWN, Warszawa, 1986-92.
9. Th. Bröcker, *Analysis I, II* (2 Auflage), Spektrum Akademischer Verlag, Heidelberg, 1995.
10. R. Strichartz, *The Way of Analysis*, Jones and Bartlett, Boston -London, 1995.

Prerequisites:

Examination: Pass of class exercises, written and oral examination.

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Course: **105C Mathematical analysis C II**	
Lecturer: **prof. dr hab. Stanisław Woronowicz**	
Semester: **summer**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.102105C**	*Credits:* **10**

Syllabus:

1. Real vector spaces with a norm Banach spaces. Spaces of bounded linear maps and their norms. Finite-dimensional spaces. Continuity of linear maps defined of finite-dimensional spaces. Matrices as linear mapping of arithmetic spaces ($\mathbf{R}^N$ spaces). Completeness of finite-dimensional spaces. Adjoint spaces. Convex closed sets. Separation theorem (Hahn-Banach).
2. Complete metric spaces. Fixed point theorem of Banach. Applications.
3. First order differential calculus of functions of many variables. Differentiable mappings. The derivative of a mapping point (Frecht). Jacobi matrix and Jacobian. Composition of differentiable mappings and its derivative. Directional and partial derivatives. Gateau derivative. Mappings with continuous partial derivatives are differentiable. Mean value theorem. Local invertibility of differentiable mappings. Examples. Implicit function theorem. Examples.
4. Introduction to differential geometry: Loal co-ordinate systems. Transformations of local co-ordinates. k-dimensional surfaces (manifolds) in $\mathbf{R}^N$. Surfaces given by a system of equations. Surfaces introduced by parametrization. Vectors and directional derivatives. Tangent vectors and tangent spaces to a k-dimensional surface in $\mathbf{R}^N$.
5. Higher order of differential calculus: Multilinear maps. Derivatives of higher order. Partial derivatives of higher order. Commutativity of partial derivatives. Taylor formula for functions and mappings. Extremes and stationary points of of many variables. Methods of finding whether a given stationary point is a maximum, minimum or a saddle point. Constrained extrema. Lagrange multipliers.

6. Ordinary differential calculus: First order differential equations. Integrating factor. Elementary methods of solving for first order differential equations. Lowering of order for higher order differential equations. Theorem of existence and uniqueness for solutions of system of first order differential equations. Pointwise and uniform convergence of a sequence of functions. Completeness of space C[a,b]. Role of Lipshitz condition in the theorem on existence and uniqueness. Systems of homogeneous linear first order differential equations with constant coefficients. A resolvent of a system of homogeneous linear first order differential equations. Inhomogeneous linear equations. Dynamical systems. Existence and uniqueness theorem for equations of higher order. Linear equations of higher order. 7. Multidimensional Riemann integral: Cubs in $\mathbf{R}^N$. Partitions of cubs. Riemann integral over cubs - definition. Integrability of piecewise continuous function. Zero measure sets. Smooth hypersurfaces as zero measure sets. Multidimensional and multiple integrals. Integrals over closed domains with piecewise smooth boundaries. Passing to multiple integrals - putting the correct limits for multiple integrals. Basic properties of integral: linearity and additivity with respect to the integration domain. Change of variable in multidimensional integrals. Differential forms and related operations.
Literature: 1. Lecture notes. 2. L. Schwartz, *Kurs analizy matematycznej.* 3. W. Rudin, *Podstawy analizy matematycznej.* 4. K. Maurin, *Analiza* cz.1- *Elementy.* 5. W. I. Arnold, *Równania różniczkowe zwyczajne.* 6. K. Kuratowski, *Wstęp do teorii mnogości i topologii.*
Prerequisites:
Examination: Pass of class exercises. Written and oral examination.

Mathematics 2nd year

Course: **201A Mathematics A III**	
Lecturer: **prof. dr hab. Jan Blinowski**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.103201A**	*Credits:* **10**
Syllabus: 1. Linear differential equations. 2. Rieman integral of many variable functions. 3. Surface integrals. 4. Extrema with boundary conditions. 5. Holomorphic functions: elementary definitions and properties. Note: Lecture is dedicated to BSc students.	
Literature: 1. W. Krysicki, L. Włodarski, *Analiza matematyczna w zadaniach.*	

2. F. Leja, *Rachunek różniczkowy i całkowy.* 3. M. Grabowski, *Analiza matematyczna.* 4. E. Karaśkiewicz, *Zarys teorii wektorów i tensorów.* 5. G. Fichtencholz, *Rachunek różniczkowy i całkowy.*
Prerequisites: Mathematics A (semester I and II).
Examination: Pass of class exercises, written and oral examination.

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Course: **201B Mathematical analysis B III**	
Lecturer: **dr hab. Wiesław Pusz**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.103201B**	*Credits:* **10**

Syllabus:

The third part of the mathematical analysis course. The aim of the course is to supply the basic theoretical information and to present the basic methods for.

- solving systems of the first order ordinary differential equations (systems of linear differential equations with constant coefficients in particular)
- solving higher order differential equations
- investigating functions on surfaces (extrema of function on surface)
- evaluating multiple integrals (Fubini Theorem, changing variables)
- evaluating integrals depending on parameters
- evaluating integrals over surfaces (arc length of a curve, area of a surface, elements of the theory of differential forms, Stokes formula, scalar and vector potentials)
- investigating functions of a complex variable (holomorphic functions, classification of singular points, evaluating contour integrals)

Literature:

1. F. Leja, *Rachunek różniczkowy i całkowy*.
2. F. Leja, *Funkcje zespolone.*
3. W. Rudin*, Podstawy analizy matematycznej*.
4. K. Maurin, *Analiza cz.1 - Elementy*.
5. K. Kuratowski, *Wstęp do teorii mnogości i topologii.*

*Prerequisites:*Mathematical analysis I, II (B lub C), Algebra.

Examination: Pass of class exercises, written and oral examination.

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Course: **201C Mathematical analysis C III**	
Lecturer: **prof. dr hab. Paweł Urbański**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **11.103201C**	*Credits:* **10**

Syllabus:

1. Analysis on submanifolds of affine spaces: tangent vectors and covectors, Lagrange multipliers, differential forms and densities, orientation of submanifolds, integration of forms and densities, Stokes theorem, vector analysis.
2. The theory of analytical functions: analytic and holomorphic functions, Cauchy formulae, analytic prolongation, multivalued functions, singularities of analytical functions, residua - theory and applications, meromorphic functions.
3. Theory of generalised functions (distributions): elementary operations on distributions, convolution of functions and distributions, the Fourier transformation, equations in the space of distributions, periodic distributions, Fourier series.

Literature:
Lecture notes will be available in November 1998.

1. L. Schwartz, *Kurs analizy matematycznej*.
2. K. Maurin, *Analiza* cz.2.
3. M. Spivak, *Analiza na rozmaitościach*.
4. L. Schwartz, *Metody matematyczne w fizyce*.

Prerequisites: Mathematical analysis C I and C II.

Examination: Oral and written examination.

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Course: **206 Mathematical methods of physics (a)**	
Lecturer: **prof. dr hab. Jacek Tafel**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **11.103206**	*Credits:* **7,5**

Syllabus:

1. Basic definitions of group theory.
2. Point groups.
3. Group representations and character theory.
4. Lie algebras.
5. Elements of differential geometry.
6. Lie groups and their algebras.
7. Important properties of Lie group representations.
8. Lie groups in physics.

Literature:

1. A Trautman, *Grupy i ich reprezentacje* (lecture notes).
2. A.I. Kostrykin, *Wstęp do algebry.*
3. M. Hamermesh, *Teoria grup w zastosowaniu do zagadnień fizycznych.*

Prerequisites: Mathematical analysis, Algebra and geometry.

Examination: Pass of class exercises, examination.

***

Course: **207 Mathematical methods of physics (b) (Introduction to theory of special functions)**	
Lecturer: **dr hab. Jan Dereziński**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **11.103207**	*Credits:* **7,5**

The course is devoted to the theory of the most elementary special functions and related mathematical concepts.

Syllabus:

1. Additional material on complex analysis
2. The Gamma function (the Euler integrals, infinite products, the saddle point method used to derive the Stirling formula, the asymptotic expansion of the Gamma function).
3. Differential equations in a complex domain.
4. The Bessel equation, the Bessel, Hankel and Neumann functions, the separation of variable in the Helmholz equation.
5. Elements of the theory of Hilbert spaces, orthonormal bases, projections.
6. Orthogonal polynomials - general theory.
7. Classical orthogonal polynomials (in particular, the Hermit, Tchebyshev and Legendre polynomials).

8 Spherical harmonics.

Literature:

1. E. Whittaker, G. Watson, *Analiza Współczesna.*
2. Lecture notes

Prerequisites: Mathematical Analysis B or C.

Examination: Pass of class exercises, written and oral examination.

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Course: **209A Modern theoretical mechanics**	
Lecturer: **dr Zygmunt Ajduk**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **13.203209A**	*Credits:* **7,5**

Syllabus:

1. Nonrelativistic mechanics of many particles systems
   Motion and its relativity. Principles of dynamics, Galileo principle of relativity, conservation laws. Motion in electromagnetic field and in central conservative forces. Constraints, Lagrange equations of the first and second kind. Equilibrium position and small oscillations.
2. Nonrelativistic mechanics of rigid bodies.
   Motion of rigid bodies, physical pendulum, free and heavy symmetric tops.
3. Analytical mechanics.
   Hamilton principle, Noether theorem. Hamilton canonical equations, Poisson brackets, general equation of mechanics, Poisson-Jacobi equation. Deterministic chaos, atractors, bifurcations.
4. Relativistic mechanics.
   Special Lorentz transformation, Einstein principle of relativity, principles of dynamics, Hamilton principle, motion in electromagnetic field.

Literature:

1. W. Rubinowicz, W. Królikowski, *Mechanika teoretyczna.*
2. G. Białkowski, *Mechanika klasyczna.*
3. L. Landau, E. Lifszyc, *Mechanika.*

Prerequisites:

Examination: Pass of class exercises, written and oral examination.

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Course: **209B Classical mechanics**	
Lecturer: **prof. dr hab. Wojciech Kopczyński**	
Semester: **winter and summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **13.203209B**	*Credits:* **10**

Syllabus:

1. Kinematics
   Time, space, a material point. The Einstein summation convention. The velocity and the acceleration. The triad of Frenet, the decomposition of acceleration onto the tangent and normal components. The flat motion, its complex description, the radial and transversal components of velocity and acceleration. Geometry and kinematics of the rotations, the

angular velocity, comparison of motion with respect to two different frames of reference.

2. Principles of Newtonian dynamics
   Analysis of the I-st and the II-nd principle of dynamics from the historical and contemporary point of view.
3. Elements of variational calculus
   Formulation of the problem, the Euler-Lagrange equations. The brachistochrone. The first integrals of the Euler-Lagrange equations. The conditional extrema.
4. The equations of mechanics as a variational problem
   Without the constraints, the equations of mechanics are example of the Euler-Lagrange equations. Arbitrariness of co-ordinates. Incorporation of the constraints. The first integrals of the Lagrange equations.
5. The symmetries and the conservation laws, the Noether theorem
   The definition of symmetries. The variations with the time variation. The Noether identity. The transformations of the Galilei group as symmetries of mechanics. The Lorentz group and the relativistic lagrangian.
6. One-dimensional problems
   The discussion of one-dimensional motion. The period of the motion, isochronism. The harmonic oscillator. The flat pendulum. The isochronic pendulum. The parametric resonance.
7. Small vibrations of systems with many degrees of freedom
   Motion near equilibrium. The normal frequencies and co-ordinates. The three-dimensional oscillator and its dynamical symmetry.
8. The motion under the influence of the central force
   The general discussion of the motion under the influence of the central force. The Kepler problem. The dynamical symmetry in the Kepler problem.
9. The rigid body
   The definition of the rigid body. The two frames of reference connected with a rigid body. The angular velocity. The Euler angles. The kinetic energy and the tensor of inertia. The properties of the tensor of inertia. The angular momentum and the tensor of inertia. The equations of motion of the rigid body; the Euler equations. The spherical free top. The symmetric free top. The asymmetric free top. The symmetric heavy top.
10. The relativistic mechanics
    The principles of the relativity theory. The Lorentz transformations. Minkowski space-time, the Lorentz and Poincaré groups. The world-line, the proper time, the ideal clock, the four-velocity and the four-acceleration. The lagrangian of a free particle. The relativistic energy and momentum. The lagrangian description of the interaction between particles and fields. The interaction with a scalar field. A charged particle interacting with the electromagnetic field.
11. The canonical formulation of mechanics
    The purpose of the canonical formulation. The Legendre transformation. The canonical equations of Hamilton. Examples of hamiltonians. The Poisson brackets.; their definition, algebraic properties, the Jacobi-Poisson theorem about first integrals. Examples of calculation of the Poisson brackets. The variational principle for the Hamilton equations. The fundamental integral invariant of mechanics. The Jacobi variational principle. The universal integral invariant of Poincaré. The Lee Hwa Chung theorem. Higher integral invariants, the Liouville theorem. The Poincaré theorem about return. The canonical transformations. The Hamilton-Jacobi equation.
12. The elements of continuum media mechanics

The notion of continuum media. The local and substantial derivatives. The continuity equation. The dynamical principles of Cauchy. The Cauchy theorem about existence of the stress tensor. The material equations. The Euler fluid. The Navier-Stokes equation.
Literature: 1. W. Rubinowicz, W. Królikowski: *Mechanika teoretyczna.* 2. G. Białkowski: *Mechanika klasyczna.*
Prerequisites: Physics I, II, III, Mathematics.
Examination: Pass of class exercises on the basis of solving problems at home and colloquia, written and oral exams.

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Course: **301B Quantum mechanics I**	
Lecturer: **dr hab. Marek Olechowski**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **13.205301B**	*Credits:* **10**
Syllabus: 1. Basic definitions in quantum mechanics. 2. Schrödinger equation. 3. Bound states. 4. Collision theory. 5. Symmetries in quantum mechanics. 6. Spin. 7. Perturbation calculus. 8. Radiation. 9. Relativistic wave equation.	
Literature: 1. L. Schiff, *Mechanika kwantowa.* 2. L. Landau, E. Lifszyc, *Mechanika kwantowa.*	
Prerequisites: Mathematical analysis I-III (B or C), Algebra (B or C). Physics I-IV, Classical mechanics or Modern theoretical mechanics.	
Examination: Written and oral examination.	

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Course: **302B Introduction to quantum theory of atomic nuclei**	
Lecturer: **prof. dr hab. Stanisław G. Rohoziński**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **13.506302B**	*Credits:* **5**

The lecture is an elementary (based on the quantum mechanics I) introduction to the theory of nuclear structure. On the one hand it is a continuation of the quantum mechanics I applied to nuclear systems. On the other hand it deals with an introductory description of quantum states of nucleons in nuclei and construction of quantum nuclear models.

Syllabus:

Components of atomic nuclei: protons and neutrons. Isotopic spin. Nuclear forces and their symmetries. Nuclear two-body problem - deuteron. Collisions of nucleons. Determination of nuclear forces - the inverse problem in quantum mechanics. Nuclear three-body problem - tryton, three-body forces. Nuclear mean-field potential. A nucleon in mean-field. Shell model and the Nilsson model. Nuclear deformation. A nucleon weakly bounded - limits of nuclear stability. Classical nuclear models: the liquid drop model, the rigid body model. The quantization of classical models. The collective model of the nucleus.

Literature:

1. G. Györgyi, *Zarys teorii jądra atomowego.*
2. J.M. Eisenberg, W. Greiner, *Nuclear Models.*
3. S.G. Nilsson, I. Ragnarsson, *Shapes and Shells in Nuclear Structure*.

Prerequisites:
Suggested: Physics IV, Classical mechanics, Mechanics of continuous media, Introduction to the nuclear and elementary particle physics
Required: Quantum mechanics I

Examination: Pass of class exercises, written and oral examination.

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Course: **305 Electrodynamics of continuous media**	
Lecturer: **prof. dr hab. Jan Blinowski**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **13.206305A**	*Credits:* **7,5**

Syllabus:

1. Electrostatics in vacuum.
2. Electrostatics and thermodynamics of dielectrics.
3. Steady currents.
4. Magnetostatics, thermodynamics of magnetic media.
5. Time dependent fields and currents. Maxwell equations and conservation laws.
6. Propagation of electromagnetic waves.
7. Radiation.

Literature:

1. J. D. Jackson *Elektrodynamika klasyczna.*
2. L. Landau, E. Lifszyc *Elektrodynamika ośrodków ciągłych.*

*Prerequisites:*Suggested: Classical mechanics.

Examination: Pass of class exercises, written and oral examination.

Course: **305B Electrodynamics and elements of field theory**	
Lecturer: **prof. dr hab. Józef Namysłowski**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **13.206305B**	*Credits:* **7,5**
Syllabus: 1. Electrostatics, 2. Boundary-Value Problems, 3. Complete Set of Functions, 4. Dielectrics, 5. Magnetostatics, 6. Time-Varying Electrodynamics, 7. Special Theory of Relativity, 8. Dynamics of Charged Particles, and of Electromagnetic Field 9. Special Anti-Theory of Relativity (an example of total misunderstanding of Special Relativity by the representative of New Age, Fritjof Capra).	
Literature: 1. J. D. Jackson, *Classical Electrodynamics*, John Wiley and Sons, Inc., New York, London, Sydney, Toronto, Second Edition 1975, 2. L. D. Landau and E. M. Lifszyc, *Field Theory*, Second Edition.	
Prerequisites: Mathematical methods of physics, Quantum mechanics I, Classical mechanics.	
Examination: Pass of class exercises, two colloquia, written and oral examination.	

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Course: **309B Introduction to elementary particle physics**	
Lecturer: **dr hab. Marek Olechowski**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.506309B**	*Credits:* **2,5**
Syllabus:	
Literature: 1. F.E. Close, *Kosmiczna Cebula.* 2. F.E. Close, *An introduction to quarks and partons.* 3. E.W. Kolb, M.S. Turner, *The early Universe.*	
Prerequisites: Physics IV, Quantum mechanics I	
Examination: Written examination.	

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Course: **313 Mechanics of continuous media**	
Lecturer: **prof. dr hab. Jarosław Piasecki**	
Semester: **winter**	*Lecture hours per week:* **3** *Class hours per week:* **2**
Code: **13.205313**	*Credits:* **6,5**
Syllabus: 1. Introduction: the notion of continuum, the object of continuum mechanics. 2. Tensors and elementary differential geometry. 3. Kinematics of a continuum: Description of the motion (the Lagrange and the Euler pictures), Description of deformations. 4. Dynamics of a continuum: Stress tensor, equations of motion, conservation laws. 5. Hydrodynamics of an ideal fluid: Euler's equation of motion, hydrostatics, Bernoulli equation, waves. 6. Hydrodynamics of a viscous fluid: Navier-Stokes equation, energy balance (phenomenon of dissipation), sound waves, incompressible flows, Reynold's number, turbulence. 7. Linear elasticity theory of solids: Linear approximation, equations of the theory of elasticity, examples of static and dynamic problems.	
Literature: L.Landau, E.Lifszic, Hydrodynamika oraz Teoria sprężystości.	
*Prerequisites:*Classical mechanics.	
Examination: Pass of class exercises and examination.	

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Course: **322 Introduction to classical and quantum field theory**	
Lecturer: **prof. dr hab. Krzysztof Meissner**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **1**
Code: **13.206322**	*Credits:* **6,5**
Syllabus: Classical fields, symmetries, conservation principles, scalar and spinor fields, symmetry braking, Higgs mechanism, field quantisation, trajectory integrals, S matrix. The lecture (together with Modern methods of quantum field theory, course number 455) introduces to the methods of quantum field theories. The final goal is to introduce QED, QCD and electroweak theory as theories of high energy elementary processes. The lecture also founds a theoretical basis for phenomenological lecture.	

Literature: 1. S. Pokorski, *Gauge Field Theories.* 2. J. Bjorken, S. Drell, vol. 1: *Relativistic Quantum Mechanics,* vol. 2: *Relativistic Quantum Fields.* 3. C. Itzykson, J. B. Zuber, *Quantum Field Theory*.
Prerequisites: Quantum mechanics I, Classical electrodynamics
Examination: Pass of class exercises. Oral and written examinations.

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Course: **333 Quantum mechanics 3/2**	
Lecturer: **prof. dr hab. Krzysztof Wódkiewicz**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **0**
Code: **13.206333**	*Credits:* **4**
Syllabus: 1. The phase space. Phase space in quantum mechanics. Coherent states and the phase space. The Wigner function and other quasi-distribution functions in phase space. Generalised quasi-distribution functions in phase space for arbitrary operator orderings. Feynman path integral in phase space. Phase space for spin. Spin coherent states. Feynman path integral in phase space. 2. Bell inequalities and hidden parameters. Local realities in quantum correlations. Einstein Podolsky Rosen (EPR) correlations. Einstein ghostfield. Entangled states. variables and the EPR correlations. Hidden variables and Bell inequalities. Quantum Malus law. Classical limit of EPR correlations. Quantum ghost-fields in the EPR correlations. Reality and nonlocality on photon correlations. Greenberger Horne and Zeilinger (GHZ) correlations. Entropic Bell inequalities. 3. Quantum measurement theory. Operational approach to quantum measurements. Operational approach to quantum theory of measurement. Quantum propensity and algebras of operational observables. Quantum filters and entanglement during measurements. Operational measurements of Q and P. Operational uncertainty relations. Operational measurement of the quantum phase. Quantum trigonometry. Quantum decoherence. Zeno measurements. Quantum jumps.	
Literature: Selected original papers.	
Prerequisites: Quantum mechanics I, Electrodynamics.	
Examination: Oral examination.	

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Course: **401 Statistical physics I**	
Lecturer: **prof. dr hab. Marek Napiórkowski**	
Semester: **winter**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **13.207401**	*Credits:* **7,5**

Syllabus: 1. Introduction to probability theory. 2. Classical and relativistic dynamics in phase space. 3. Classical and quantum probability distributions in phase space. 4. Equilibrium statistical ensambles. Entropy. 5. Applications of statistical ensambles. 6. Bose and Fermi gases. 7. Theory of real gases. 8. Elements of phase transitions. 9. Dynamical approaching of equilibrium states. 10. Elements of fluctuation theory.
Literature: 1. L. Landau, L. Lifszyc, *Fizyka Statystyczna.* 2. K. Huang, *Fizyka Statystyczna*.
Prerequisites: Quantum mechanics I, electrodynamics.
Examination: Pass of class exercises. Oral and written examination.

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Course: **402 Thermodynamics**	
Lecturer: **dr Krzysztof Rejmer**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **13.206402**	*Credits:* **5**
Syllabus:	
Literature:	
Prerequisites:	
Examination: Pass of class exercises. Oral and written examination.	

Part II: Experimental Physics

Course: **102A Physics A I – Mechanics**	
Lecturer: **dr hab. Zygmunt Szefliński**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **6**
Code: **13.201102A**	*Credits:* **12**

This course is intended to give an introductory treatment of classical mechanics based on demonstration of experiments. The primary objectives are to provide the student with an understanding of mechanics as a quantitative science, based on observation and experiment and with an appreciation of the experimental laws and fundamental principles that describe the behaviour of physical world. The necessary mathematical techniques are introduced at the most propitious moments within the development of the central theme - physics. The course is elementary in that it deals with the basic elements of physics, a point worth recognising. In order to deepen the knowledge students solve the problems.

Syllabus:

1. The rudiments of techniques of effective learning. Methods of the solution of problems in physics. How to pass examinations.
2. Scope of physics. Scale of physical quantities. Units of measurements. Fundamental units of space, time and mass. Measurements and its accuracy. Role of mathematics in physics. Vector and scalar quantities. Vector operations. Vectors and laws of physics. Fundamental interactions, interactions of elementary particles. Role of model in physics, examples.
3. Elements of static's. Rigid body. Centre of mass. Equilibrium of a rigid body.
4. Kinematics. Position, displacement, velocity and acceleration of the particle. Linear motion of a particle. Physical interpretation of the derivative. Motion in space. Angular co-ordinates.
5. Laws of dynamics. The inertia of matter. The concept of force. Inertial mass, weight and momentum. Conservation of momentum. Interaction between bodies. Friction, inertial forces. Collisions. Elastic and inelastic collisions.
6. Work and energy. Kinetic energy. Force and potential energy in conservative systems. The work-energy theorem. Conservation of energy in conservative systems. Power.
7. Central forces. Centripetal and centrifugal forces. Low of universal gravitation. Kepler's laws of planetary motion. Solar system. Harmonic oscillator. Many body systems. Conservation laws.
8. Dynamics of the rigid body. Angular speed and acceleration. Energy. Moment of inertia. Angular momentum. Spinning top in simple approach. Rigid body pendulum. Elastic properties of the rigid body.
9. Galilean relativity. Inertial frame of reference. Noninertial systems. Galileo transformation. Motion in noninertial frame of reference. Inertial forces.
10. Special relativity. Speed of light as limit of velocity. Principle of relativity and Lorentz transformation. Time dilatation. Equivalence of mass and energy. Relativistic dynamics.
11. Photon. Photon as a zero mass particle. Photon energy. Photoelectric effect. Momentum of photon. Compton effect. Pressure of the radiation.

Literature:

1. R. Resnick, D Halliday, *Fizyka 1*, PWN, 1996.
2. M.A.Herman, A. Kalestyński, L. Widomski, *Podstawy Fizyki,* PWN, 1997.
3. A.K. Wróblewski, J.A.Zakrzewski, *Wstęp do Fizyki* t. I, PWN, 1984.
4. J. Orear, *Fizyka* t. I , WNT.
5. C. Kittel, W.D. Knight, M.A. Ruderman, *Mechanika*, PWN; (Kurs Berklejowski).
6. R. Feynman, *Wykłady z Fizyki* t. I, PWN.
7. I.W.Sawiliew, *Kurs Fizyki* t. I, PWN.

Problems:

1. A.Hennel, W. Krzyżanowski, W Szuszkiewicz, K.Wódkiewicz, *Zadania i problemy z fizyki*, PWN.
2. Problems in R. Resnick, D. Halliday, *Fizyka 1.*
3. Problems in J. Orear, *Fizyka.*

Examination: Written and oral examination.

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Course: **102B Physics B I** and **102C Physics C I - Mechanics**	
Lecturer: **dr hab. Teresa Rząca-Urban**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **13.201102BC**	*Credits:* **12**

The course is designed to give students a basic understanding of the key concepts of classical mechanics and special relativity, which will underpin many courses given in later years. It is also recommended for students intending to study other science s who wish to extend their knowledge of elementary physics. Lecture courses will be including many demonstrations to illustrate applications of some of the topics covered.

Syllabus:

1. Scalars and vectors, frames of reference, velocity, acceleration, Galilean transformation.
2. Newton's three laws, inertial frames, inertial mass, the equations of motion.
3. Elementary applications of Newton's laws to static and dynamic problems, frictional forces, Hooke's law.
4. Simple harmonic motion- harmonic oscillator, damped oscillations, forced oscillations, resonance.
5. Circular motions, angular velocity vector.
6. The motion in noninertial reference frames, centrifugal force, Coriolis force, the Foucault pendulum, weather patterns.
7. Angular momentum, torque.
8. Work done by forces, potential and kinetic energies, power.
9. Constants of the motion, conservation of the linear momentum, angular momentum and energy.
10. Gravitational force, gravitational potential energy, motion under central forces, effective potentials, two-body problem, reduced mass.
11. Kepler's laws for planetary motion.
12. Elastic and inelastic collisions, centre of mass.

13. Rigid body motion, rotational motion (fixed axis), the moment of inertia, physical pendulum, the inertia tensor, precession (simple treatment).
14. Relativistic transformations of length and time, Lorentz transformation, twin paradox. Lorentz transformation of velocity, conservation of momentum, velocity-dependence of mass, conservation of energy for relativistic systems, rest energy of a particle, relation between total energy, mass and momentum of particle.
15. Some things never change-Lorentz invariants.

Literature:

1. C. Kittel, W. D. Knight, M. A. Ruderman, *Mechanika* (t. I kursu Berkeleyowskiego).
2. A.K. Wróblewski, J. A. Zakrzewski, *Wstęp do fizyki,* t.I i t. II cz.l .
3. J. Orear, *Fizyka,* t. I i II.
4. W. Karaśkiewicz, *Zarys teorii wektorów i tensorów,* rozdz.1-3.
5. A. Hennel i inni, *Zadania i problemy z fizyki,* cz. I.

Prerequisites:

Examination: Two colloquia, written examination (test + problems).

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Course: **104 Principles of experimental error analysis**

Lecturer: **dr hab. Teresa Tymieniecka**

Semester: **winter**	*Lecture hours per week:* **2 hours/week in half a semester** *Class hours per week:* **1 hour/week**
Code: **13.201104**	*Credits:* **3**

Syllabus:

The course is some comprehensive introduction to statistical analysis of data and their graphical presentation as well as to fundamental idea of uncertainty in measurement. This is addressed to students without any experience in experimentation and in extracting information from data.

The workshop pedagogical approach is used. Firstly we make listeners realise that there are quantities in nature, which instead of one value can have a large variety of possible values often appearing with different probabilities; their values are provided either by nature or by act of measure. The students are guided to discover the main statistical concept: description of these quantities with one or two values and estimate of their precision. To explore statistical principle and to apply them the simplest statistical models are introduced (Gauss, Poisson, binomial) together with the simplest test based on the models (the 3sigma test, the chi-square test, the plus- minus test). Then the statistical interpretation of measurement is introduced together with rules of error propagation. Optimisation comes together with the least squares methods applied to linear problems.

The course is designed to foster active learning by minimising lectures and replacing them with hands-on activities. Students are expected to perform some home experiments which permit them to explore the meaning of concepts such as randomness, variability, sampling, confidence, tendency, significance and get familiar with experimental designing.
The ISO terminology is used.

Literature:
1. Copies of transparencies from all the lectures will be available in the local library.
2. A.K.Wróblewski, J.A.Zakrzewski, Wstęp do Fizyki, rozdz. I.8-10 wraz z przypisem I.2-4.
3. G.L.Squires, Practical Physics.
4. H.Hänsel, Podstawy rachunku błędów.
5. John R.Taylor, An Introduction to Error Analysis.
6. H.Abramowicz, Jak analizować wyniki pomiarów?

Prerequisites: Suggested: some basic knowledge of differential calculus.

Examination: A written colloquium (arithmetical problems) and a written project (a physical experiment designed and performed as a homework).

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Course: **106A Physics A II – Electricity and magnetism**	
Lecturer: **dr hab. Jacek Ciborowski**	
Semester: **summer**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **13.202106A**	*Credits:* **10**

Syllabus:
1. Introduction to the field theory.
2. Scalar and vector potential.
3. Constant electric and magnetic fields. Polarisation and magnetisation. Boundary conditions.
4. Constant electric current, resistance, capacitance.
5. Electromotive force, Ohm's law, Kirchhoff laws.
6. Currents in gases and liquids, laws of electrolysis.
7. Lorentz force, Ampere's force.
8. Biot-Savart's law.
9. Time dependent electric and magnetic fields; induction.
10. Maxwell equations, charge conservation.
11. Energy density of electromagnetic field.
12. Units.

Literature:
1. A.K. Wróblewski i J. Zakrzewski, Fizyka, t.II cz.2.
2. R. Resnick i D. Halliday, Fizyka, t.II.
3. E. Purcell, Elektryczność i magnetyzm.
4. R. Feynmann, Feynmanna wykłady z fizyki, t.II cz.1.
5. S. Szczeniowski, Fizyka Doświadczalna, cz.3.
6. S. Frisz i A. Timoriewa, Kurs fizyki, t.II.

Prerequisites: Physics I, Mathematics I

Examination: Two colloquia, written examination.

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Course: **106B and 106C Physics B II and CII –Electromagnetism**	
Lecturer: **prof. dr hab. Jan A. Gaj**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **4**
Code: **13.202106B**	*Credits:* **10**

Syllabus:

Part A: "Kinematics" of fields and currents (description without rules of behaviour)

1. Electric field. Electric charge and intensity of electric field.
2. Differentiation and integration of fields: gradient, rotation, divergence, circulation, flux and their intuitive representation. Field lines.
3. Electric current and current density, microscopic picture. Conductors and insulators. Kirchhoff's first rule and conservation of charge.
4. Magnetic field and magnetic moment, Lorentz force, Hall effect.

Part B "Dynamics" of fields and currents (fundamental laws of their behaviour)

1. Electrostatic field: its potential character, Gauss' law (integral and local form), vector D. Condenser and its capacity, depleted layer, field effect transistor. Coulomb's law. Screening, the method of images. Energy in electric field.
2. Electric current: Ohm's law and its local form, mobility and concentration of charge carriers, deviations from Ohm's law. Microscopic picture of Ohm's law, model of viscous force, relaxation time. Joule's heat. Sources of electric current: electromotive force and internal resistance. Optimal resistance of a load.
3. Electric circuits: charging of a capacitor through a resistor, integrating and differentiating circuits, second Kirchhoff's rule, measurements of current and voltage, Wheatstone bridge, compensation measurements.
4. Alternating currents: intensity measurements, complex number formalism.
5. Magnetic field: Ampere's law – integral and local form, the law of Biot and Savart, vector H, examples. Absolute definition of ampere. Displacement current.
6. Electromagnetic induction: Faraday's induction law, Lenz rule. Complete set of Maxwell equations in vacuum. Eddy currents, inductance and mutual inductance, circuits with inductance, energy in a coil. LC circuit, its oscillations and resonance. Tesla transformer.
7. Digression: Canonical ensemble
8. Thermal equilibrium, notion of temperature, empirical temperature. Probability distribution (discrete and continuous case), averaging. Ergodic hypothesis, canonical distribution.

Part C Influence of fields on matter

1. Dielectric polarisation: electric dipole moment, polarisation vector, polarizability, and susceptibility. Elastic and orientation polarisation mechanisms. Influence of geometry of the system, Clausius-Mossotti equation. Temporal dependence in po larisation: resonance, relaxation. Dielectric function, polarisation and conductivity. Plasma oscillations.
2. Magnetism of matter: dia-, para-, and ferromagnetism, magnetisation and susceptibility, phenomenological description of ferromagnetism. Solenoid with a core, transformer, DC generator and DC electric motor. Microscopic mechanisms in magnetism: diamagnetism, paramagnetism, mean field model.

3. Electric conduction in liquids and gases: electrolysis, galvanic cells, electric discharge in gases, neon lamp.

Literature:

1. Lecture notes.
2. R. P. Feynman i in., *Feynmana wykłady z fizyki.*
3. A.Piekara *Elektryczność, materia i promieniowanie.*

Supplementary literature:
A. Chełkowski *Fizyka dielektryków.*

Prerequisites: Physics I

Examination: Pass of class exercises, written and oral examination.

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Course: **202A Physics A III - Vibrations and Waves**

Lecturer: **prof. dr hab. Michał Nawrocki**

Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **13.203202A**	*Credits:* **10**

This is a simpler version of a traditional course. Its main goals are to provide students with the opportunity to acquire an intuition for the physical effects and to resolve simple physical problems. This course places significant emphasis on lecture demonstration and on the relation between the course material and everyday life.

Syllabus:

1. Vibrations
   Free, damped and forced harmonic vibrations. Resonance.
   Non-linear vibrations.
   Self-induced vibrations;
   Parametric resonance.
   Coupled vibrations;
2. Waves.
   Wave motion.
   Elastic waves.
   Electromagnetic waves.
   Wave optics.
   Geometrical optics.
   Light polarisation.
   Absorption, dispersion, scattering.

Literature:

1. R. Resnick, D. Halliday, *Fizyka I.*
2. D. Halliday, R. Resnick, *Fizyka II.*
3. I.W.Sawieliew, *Wykłady z fizyki,* t.I i II.
4. S. Pieńkowski, *Fizyka doświadczalna-optyka.*
5. Sz. Szczeniowski, *Fizyka doświadczalna-optyka*.
6. Januszajtis, *Fizyka dla politechnik □ fale*.
7. J. Orear, *Fizyka,* WNT 1990.
8. J. Ginter, *Fizyka III*, t.I i II, skrypt dla NKF.
9. Lecture notes.

Prerequisites: Physics I and II, Mathematics I and II.
Examination: The final exam consists of two parts: written and oral. The written part is open for students who obtained a better score than 50% for each part (test and problems) of colloquia 1 and/or 2. The oral part is open for students who: a) obtained a better score than 50% for each part of colloquia 1 and 2 and participated in the written part of the final exam, or b) obtained a better score than 50% for each part of colloquia 1 or 2 and the written part of the final examination.

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Course: **202B Physics B III – Waves and oscillations**	
Lecturer: **prof. dr hab. Andrzej K. Wróblewski**	
Semester: **winter**	*Lecture hours per week:* **4** *Class hours per week:* **4**
Code: **13.203202B**	*Credits:* **10**

Syllabus:

The course deals mainly with oscillations and waves with special stress on the physics of electromagnetic waves in the visible region of the spectrum, i.e. optics. Similarity of the mathematical formalism in description of various oscillations and waves (i.e. harmonic oscillator equation or classical wave equation) makes it possible to consider jointly all oscillations and waves (mechanical, acoustic, visible light).

The course is divided into following parts:

1. Oscillations of systems with one degree of freedom (mathematical and physical pendulum, damped oscillations, forced oscillations, RLC circuits, addition of oscillations).
2. Oscillations of systems with many degrees of freedom (coupled pendulums, coupled circuits, mechanical and electric filters, oscillations of continuous systems (strings, rods), Fourier analysis of oscillations).
3. Waves (wave equation, phase and group velocity, Doppler effect, surface water waves, pressure waves in rods, acoustic waves, reflection, refraction, and total internal reflection of waves, wave packets).
4. Electromagnetic waves (prediction from Maxwell equations, plane waves, dipole radiation, energy and momentum of electromagnetic waves – the Poynting vector, reflection and refraction of electromagnetic waves (Fresnel formulae), dispersion, polarisation of light due to its scattering, propagation of electromagnetic waves in anisotropic media (elements of crystal optics), retarding plates, chromatic polarisation, birefringence forced mechanically, electrically (Kerr effect), and magnetically (Cotton-Mouton effect), rotation of polarisation plane (Faraday effect)).
5. Interference and diffraction (interference of waves from two and more than two sources, interference of light in thin plates, Fraunhofer diffraction, diffraction grating, Fresnel diffraction, elements of atmospheric optics (rainbow, halo), interference and diffraction of particle beams).

The course deals almost entirely with the classic theory. Only at the very end the diffraction and interference of matter waves (electrons, neutrons) is shortly discussed.

Literature:

No single textbook corresponds strictly to the material presented in this course.

1. Sz. Szczeniowski - Fizyka doświadczalna, tom IV Optyka. 2. J. Ginter - Fizyka fal (cz. 1 i 2). 3. Crawford: Waves and Oscillations (Volume 3 of the Berkeley Course of Physics) may be used as an auxiliary source.
Prerequisites: Physics I, Physics II, I Physics Laboratory.
Examination: Pass of class exercises, written and oral examination.

***

Course: **203 Physics laboratory I (a)**	
Head: **dr hab. Tomasz Morek**	
Semester: **winter**	*Lecture hours per week:* **0** *Class hours per week:* **3**
Code: **13.202203**	*Credits:* **3,5**
Syllabus: Laboratory program includes 10 exercises (amounts depends on number of weeks in the semester) from mechanics, heat, electricity, optics and nuclear physics. The aim of these experiments is to teach students elementary experimental methods through simple exercises, which demand in manual cleverness, and to learn analysis of experimental data.	
Literature: 1. Source information about exercises is included in special instructions (which are available in the secretariat of the Laboratory) and in the following text-books: 2. H.Szydłowski, Pracownia fizyczna 3. A.Zawadzki, H.Hofmokl, Laboratorium fizyczne 4. F.Kohlraush, Fizyka laboratoryjna (in special cases) Before the beginning of the laboratory work students should get acquianted with rules of the analysis of experimental results. The following books are helpful: 1. J.R.Taylor, Wstęp do analizy błędu pomiarowego 2. G.L.Squires, Praktyczna fizyka 3. H.Abramowicz, Podstawy rachunku błędów 4. H.Hansel, Podstawy rachunku błędów 5. P.Jaracz, Podstawy rachunku błędu pomiarowego (preliminary version)	
Prerequisites: Principles of experimental error analysis. Introduction to techniques of measurements and preliminary laboratory.	
Examination: 10 experiments with pass-grades.	

***

Course: **204 Physics laboratory I (b)**	
Head: **dr hab. Tomasz Morek**	
Semester: **summer**	*Lecture hours per week:* **0** *Class hours per week:* **3**
Code: **13.203204**	*Credits:* **4**

Syllabus: Laboratory program includes 10 exercises (the exact number depends on number of weeks in the semester) from mechanics, heat, electricity, optics and nuclear physics. The aim of these experiments is to teach students elementary experimental methods through simple exercises, which demand in manual , and to learn analysis of experimental data.
*Prerequisites:*I Physics Laboratory (a).
Examination: 10 experiments with pass-grades.

***

Course: **205 Physics IV – Introduction to modern physics**	
Lecturer: **prof. dr hab. Jan Królikowski**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **13.204205**	*Credits:* **5**

Syllabus:

1. Wave-particle dualism.
    1. Black body radiation. Rayleigh–Jeans theory, Planck equation.
    2. Photoelectric effect, X–ray, Compton effect.
    3. Emission and absorption spectra. Bohr model of atom, ionisation energy, Franck–Hertz experiment.
    4. Diffraction and interference of photons and microparticles. Heisenberg uncertainty principle, de Broglie hypothesis. Wave function, phase and group velocity.
2. Schrödinger equation.
    1. Step potential, barrier potential, tunnelling effect. Scanning tunnelling microscope.
    2. Bound states: one–dimensional quantum well, finite and infinitive.
    3. Operators in quantum mechanics. Eigenstates eigenvectors. Observable. Orbital momentum operator, spherical functions.
    4. Hydrogen atom.
3. Atomic and molecular spectra.
    1. Zeeman effect, Stark effect, spin–orbit coupling. Many electron atoms. Pauli exclusion principle, selection rules.
    2. Molecular spectra.
4. Quantum statistics.
    1. Bose Einstein statistics, photon gas, Fermi–Dirac statistics, electron gas.
5. Elements of solid state physics.
    1. Band theory, p-n junction, transistor.

Literature:

1. H. A. Enge, M. R. Wehr, J. A. Richards, *Wstęp do fizyki atomowej.*
2. I. W. Sawieliew, *Wykłady z fizyki*, t. 3.
3. Sz. Szczeniowski, *Fizyka doświadczalna*, cz. V.

Prerequisites: Physics I, II, III, Mathematics.

Examination: Pass of class exercises, examination.

***

Course: **210 Electronics, electronic laboratory**	
Lecturer: **dr hab. Tadeusz Stacewicz**	
Semester: **winter**	*Lecture hours per week:* **3 every two weeks** *Laboratory hours per week:* **3 every two weeks**
Code: **06.503210**	*Credits:* **4**

Syllabus:

Digital integrated cirquits. Application of computers in experiments. Analog integrated circuits (amplifiers, stabilisators). Noise.
During practical laboratory work students use computer-controlled measurement setups. Students learn about standard measurement devices and electronic measurement techniques (signal-to-noise ratio enhancement, selective detection, phase detection, one- and multichanel signal analysis, methods of nuclear electronics, photon counting). Comparison of theory and experiment is discussed.

Literature:

1. H. Abramowicz, *Jak analizować wyniki pomiarów?*
2. G. L. Squires, *Praktyczna fizyka.*
3. U. Tietze, Ch. Schenk, *Układy półprzewodnikowe.*
4. P. Horovitz, *Sztuka elektroniki.*
5. T. Stacewicz, A. Kotlicki, *Elektronika w laboratorium naukowym.*

Prerequisites: Introductory laboratory, Physics I and II, Mathematics I and II.

Examination: Pass of laboratory exercises, written and oral examination.

***

Course: **212 Physical experiments under extreme conditions**	
Lecturer: **prof. dr hab. Marian Grynberg**	
Semester: **winter**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.201212**	*Credits:* **2,5**

Syllabus:

1. Low temperatures. Cooling to low temperatures. Temperature detection in low temperatures. Physical phenomena typical at low temperatures.
2. High magnetic fields. Field sources and field detection. Core magnets, superconducting magnets, Bitter and hybrid magnets. Pulse fields. Physical limitations.
3. High vacuum. Pumps. Physical phenomena used in pressure gauges.
4. Methods of submicron solid state layers production. Thickness monitoring. Physical phenomena in 2D semiconductor structures.
5. High pressure in manostates and diamond anvil cells, manometers.
6. Far infrared spectroscopy. Sources, detection (Golay cell, bolometer), monochromatisation. Differential spectroscopy.
7. Synchrotron radiation: sources, characteristics, and application to condensed matter studies.

Literature: There is no single handbook.
Prerequisites: Physics I and II, Mathematics.
Examination: Test examination

***

Course: **213 Physics V- Experimental thermodynamics**	
Lecturer: **prof. dr hab. Maria Kamińska**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **2**
Code: **13.204213**	*Credits:* **5**

Syllabus:

1. Description of thermodynamic system
2. Empirical temperature and properties of matter dependent on temperature. International Scale of Temperature.
   a. volume thermal expansion
   b. electrical thermometers
   c. pyrometers
   d. liquid crystal displays
   e. gas thermometers
3. Clapeyron's equation for ideal gas and equations for real gases. p-V-T surfaces for real substances.
4. First law of thermodynamics. Concept of internal energy, work and heat in thermodynamics. Transport of heat.
5. Molar heat capacity for ideal gas, real gases, liquids and solids. Heat of phase transitions.
6. Heat engine. Carnot cycle. Heat pump.
7. Entropy. Quasistatical, reversible and non-reversible processes.
8. Second law of thermodynamics. Thermodynamic temperature.
9. Transport phenomena (electrical conduction, heat conduction, diffusion, viscosity). Low temperatures. Joule – Thomson effect. Gas liquefier.

Literature:

1. J. Ginter, *Fizyka IV dla NKF.*
2. S. Dymus, *Termodynamika.*
3. A. K. Wróblewski, J. A. Zakrzewski, *Wstęp do fizyki*, tom 2.
4. J. Orear, *Fizyka*, tom 1.
5. W. Sears, G. L. Salinger, *Thermodynamics, Kinetic Theory and Statistical Thermodynamics.*

Prerequisites:

Examination: Pass of class exercises, written and oral examination.

***

Course: **302A Introduction to nuclear and elementary particle physics**	
Lecturer: **prof. dr hab. Jan Żylicz**	
Semester: **winter**	*Lecture hours per week:* **2** *Class hours per week:* **1**
Code: **13.505302A**	*Credits:* **4**
Syllabus: 1. First contact with the subatomic physics 2. Experimental methods of subatomic physics 3. The force between nucleons. The deuteron 4. Nuclear models 5. Spontaneous transformations and excited states of nuclei 6. Nuclear reactions in laboratory and stellar environments 7. Nuclear physics and society 8. Physics of hadrons 9. Elementary particles 10. Symmetries and conservation laws 11. Perspectives of the subatomic physics	
Literature: 10. E.Skrzypczak, Z.Szefliński, *Wstęp do fizyki jądra atomowego i fizyki cząstek elementarnych.* 1. I. Strzałkowski, *Wstęp do fizyki jądra atomowego.* 2. T.Mayer-Kuckuk, *Fizyka jądrowa.* 3. D.H.Perkins, *Introduction to high-energy physics* 4. R.J.Blin-Stoyle, *Nuclear and particle physics* For further reading: 5. K.S.Krane, *Introductory nuclear physics* 6. H.Frauenfelder, E.M.Henley, *Subatomic physics*	
*Prerequisites:*Physics I, II, III, IV.	
Examination: - two colloquia of solving problems (middle and end of the semester); - oral examination.	

***

Course: **303A Physics laboratory II (a)**	
Head: **prof. dr hab. Czesław Radzewicz**	
Semester: **winter or summer**	*Lecture hours per week:* **-** *Class hours per week:* **11**
Code: **13.205303**	*Credits:* **13,5**
Syllabus: The main purpose of this laboratory is to teach students the experimental techniques used in different areas of physics. There are approx. 40 different exercises divided into five groups: solid state physics, optics, nuclear physics, elementary particle physics, crystal structure. Students can freely select an exercise from a given group but each next exercise has to be from another group. It takes typically from 3 weeks to complete the experimental part of a given	

exercise. Students work individually and are supervised by assistants. Each exercise contains the following parts: literature study, entrance examination, experiment, data evaluation and preparation of a written report, final discussion. The report has to be written in a form of short scientific publication. Each exercise is graded by the supervising assistant. The laboratory is divided into two parts: part a (3 exercises), part b (2 exercises). The division is formal and meant only so the student can get different number of credit points.
Literature: A list of textbooks (journal papers) is provided for each exercise.
Prerequisites: Full Physics laboratory I.
Examination: Final grade is an average of the grades from the exercises completed.

***

Course: **306 Introduction to optics and solid state physics**	
Lecturer: **dr hab. Andrzej Witowski and dr hab. Tadeusz Stacewicz**	
Semester: **summer**	*Lecture hours per week:* **3** *Class hours per week:* **3**
Code: **13.206306**	*Credits:* **7,5**

Syllabus:

1. Interaction of electromagnetic radiation with matter - microscopic picture (Einstein's coefficients "semiclassical" and quantum description), macroscopic description with dielectric function, relation to measurable quantities (transmission and reflectivity). Emission of light - shape of spectroscopic line, homogenous and nonhomogenous broadening. Quantum light amplification and generation (LASER).
2. Atomic hydrogen and alkali metals states. Effect of perturbation on energy levels of atoms - Stark effect, Kerr effect, Zeeman effect and Faraday effect. Description of atoms including electronic spin - spinors.
3. Description of multi electron atoms – exchange interaction, Hartree, Hartree-Fock and central field approximation, spin-orbit interaction, LS and jj coupling - spectroscopic levels.
4. Rydberg atoms.
5. Molecules - adiabatic (Born-Oppenheimer) approximation, electronic states (bonds), motion of nuclei (rotations and oscillations). Symmetry and its effect on properties of - degeneration - interaction with EM radiation.
6. Periodic structures – Bravais lattices, base, elementary cell, symmetry of periodic structures.
7. Interaction with X-rays – diffraction on atomic and molecular gas, diffraction on periodic structures (Laue conditions, inverse lattice and Brillouin zones).
8. Liquid and quasi-crystals - their properties and description.
9. Crystals - bonds in crystals, bad structure (Bloch function and theorem), band structure investigation, free carriers and conductivity (Drude model), doping, lattice vibrations (Debye model).

Literature:

1. J. Ginter *Wstęp do fizyki atomu, cząsteczki i ciała stałego*, PWN.
2. Gołębiewski *Elementy mechaniki i chemii kwantowej*, PWN.

3. W. Kołos *Chemia kwantowa*, PWN. 4. A. Kopystyńska *Wykłady z fizyki atomu*, PWN. 5. Ch. Kittel *Wstęp do fizyki ciała stałego*, PWN.
Prerequisites: Introductory Physics course (I-V), Algebra, Analysis, Mathematical methods of physics, Quantum physics (mechanics).
Examination: Pass of class exercises, written and oral examinations.

***

Course: **307B Physics laboratory II (b)**	
Head: **prof. dr hab. Czesław Radzewicz**	
Semester: **winter or summer**	*Lecture hours per week:* **-** *Class hours per week:* **7**
Code: **13.205307**	*Credits:* **8,5**
Syllabus: The main purpose of this laboratory is to teach students the experimental techniques used in different areas of physics. There are approx. 40 different exercises divided into five groups: solid state physics, optics, nuclear physics, elementary particle physics, crystal structure. Students can freely select an exercise from a given group but each next exercise has to be from another group. It takes typically from 3 weeks to complete the experimental part of a given exercise. Students work individually and are supervised by assistants. Each exercise contains the following parts: literature study, entrance examination, experiment, data evaluation and preparation of a written report, final discussion. *The* report has to be written in a form of short scientific publication. Each exercise is graded by the supervising assistant The laboratory is divided into two parts: part a (3 exercises), part b (2 exercises). The division is formal and meant only so the student can get different number of credit points.	
Literature: A list of textbooks (journal papers) is provided for each exercise.	
Prerequisites: Full Physics laboratory I.	
Examination: Final grade is an average of the grades from the exercises completed.	

***

Course: **308 Fundamentals of X-ray and neutron diffraction**	
Lecturer: **prof. dr hab. Jerzy Gronkowski**	
Semester: **winter**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.205308**	*Credits:* **2,5**
Syllabus: 1. Basic knowledge of X-rays (X-ray tube, characteristic and continuous spectrum; synchrotron sources, synchrotron radiation characteristics, insertion devices: wigglers and undulators; interactions of X-rays with matter: real absorption, inelastic (Compton) scattering, elastic (Thomson and Rayleigh) scattering by free electrons, Rayleigh	

scattering by atoms; X-ray refraction, total external reflection, X-ray reflectometry).
2. Basic knowledge of neutrons (neutron as a particle; neutron sources: reactors and spallation sources, neutron spectra, de Broglie waves of neutrons of different energies, thermal neutrons; neutron scattering by atoms: cross section, scattering length and its dependence on atomic number, isotopic inconsistency; neutron refraction).
3. Elements of crystallography (point lattice, translation symmetry, crystallographic systems, crystal symmetry, Bravais lattices, examples of crystal structures, reciprocal lattice, Brillouin zones, Wigner-Seitz cell).
4. X-ray diffraction (Laue conditions, Bragg condition, diffraction in reciprocal lattice; kinematic theory, intensities of reflected beams, structure factor, Laue and Bragg geometry; X-ray topography and other experimental methods).
5. Neutron diffraction (structure factors for neutrons, comparison with X-rays).
6. Experimental methods of X-ray and neutron diffraction (Laue method, rotating-crystal method, Debye-Scherrer method, diffractometry, crystal structure determination).

Literature:

1. J. Gronkowski, Materiały do wykładu 1996/97 (biblioteka IFD UW)
2. Z. Trzaska Durski, H. Trzaska Durska, *Podstawy krystalografii strukturalnej i rentgenowskiej.*
3. Z. Bojarski, E. Łągiewka, *Rentgenowska analiza strukturalna.*
4. N. W. Ashcroft, N. D. Mermin, *Fizyka ciała stałego.*

Prerequisites: **Suggested:** Introduction to atomic, molecular and solid state physics or Introduction to optics and solid state physics (since 1998/99), Electrodynamics of continuous media.
Required: Physics I, II, III, IV.

Examination: Examination.

***

Course: **309A Topics in elementary particle physics**	
Lecturer: **prof. dr hab. Barbara Badełek**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.506309A**	*Credits:* **2,5**

Syllabus:

The programme varies from year to year to account for the latest results and their interpretations. It encompasses:

1. Basic ideas, classification and review of interactions.
2. Experimental methods: accelerators, beams, targets, detectors, research centres.
3. Elastic, inelastic and deep inelastic scattering of leptons on atomic nuclei and nucleons, quark-parton model, quantum chromodynamics.
4. Standard Model, (grand) unification of interactions.
5. Physics of neutrinos: cosmic, atmospheric and accelerator-made.
6. Contemporary Universe, Big Bang Model, inflation.

Literature:
The course is based on latest communications of scientific results. Therefore lecture notes are the basic reading. Copies of selected plots and diagrams are also distributed.

1. B. R. Martin and G.Shaw, "Particle Physics", 2-nd edition, J. Wiley & Sons, 1997 2. D. H. Perkins, "Introduction to High Energy Physics", 3-rd edition, Addison-Wesley, 1989 3. C. Sutton, "Spaceship neutrino", Cambridge University Press, 1992 4. F. E. Close, "Cosmic onion", Heinemann Educational Books, 1983
Prerequisites: Introduction to nuclear and particle physics.
Examination: Written test.

***

Course: **311 Introduction to biophysics**	
Lecturer: **prof. dr hab. Bohdan Lesyng**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.906311**	*Credits:* **2,5**
Syllabus:	
Literature: 1. W. Kołos, *Chemia kwantowa.* 2. M. Fikus, *Inżynierowie żywych komórek.* 3. M. Fikus, *Biotechnologia* . *Supplementary literature*: 1. P. S. Agutter et al., *Energy in Biological Systems.* 2. Ch. Cantor, P. R. Schimmel, *Biophysical Chemistry.* 3. L. A. Blumenfeld, *Problemy fizyki biologicznej.* 4. *Biologia molekularna. Informacja genetyczna,* red. Z.Lassota. 5. L. Stryer, *Biochemistry.* 6. W. Saenger, *Nucleic Acids Structure.*	
Prerequisites: Physics I, II, III, IV.	
Examination: Examination.	

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Course: **314 Physics of relativistic nuclei collisions**	
Lecturer: **prof. dr hab. Ewa Skrzypczak**	
Semester: **summer**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.506314**	*Credits:* **2,5**
Syllabus: 1. Basics of fundamental interactions and partons. 2. Experimental tools (accelerators and detectors). 3. Computer simulations as an indispensable part of experiment and data interpretation. 4. What is measured: global characteristics, characteristics of different particles production. Determination of temperature, density and size of emitting sources. Correlations. Individual events analysis. 5. Theoretical models and their predictions (including quark-gluon plasma expected by QCD).	

6. Summary of the today state of the art. 7. Planned experiments (end of XX and beginning of XXI century).
Literature: Lecture notes, review papers.
Prerequisites: Introduction to nuclear and particle physics.
Examination: Oral examination.

***

Course: **315 Physical methods of environmental studies (for students of physics and MSOŚ)**	
Lecturer: **many lecturers (coordination prof. dr hab. A. Kopystyńska)**	
Semester: **winter and summer**	*Lecture hours per week:* **2** *Class hours per week:* **0**
Code: **13.205315**	*Credits:* **5**

Syllabus:

dr Piotr Jaracz - Radioactivity in human environment a compendium of physics of radioactivity and radioactive pollution. Statistic in radiometry and dosimetry (basic notions, regulations). Detection of ionising radiation: physics and technology. Comprehension of radiation risk: history, psychometric approach to radiation risk. - 10 h

dr hab. Wojciech Gadomski - Lidar – interaction of electromagnetic radiation with matter; optical detection of air pollution; lasers and detectors; measurement systems (various kinds of lidar) - 10 h

prof. dr hab. Tomasz Szoplik - Remote sensing and satellite image processing – definition and tasks. Spatial, intensity and spectral information. Black body radiation. Solar spectrum. Absorption spectra. Resolution of imaging systems. Synthetic aperture optics. Convolution and local convolution. Digital and optical methods of convolving. Rank order filters. Morphological filters. Histogram and its modification. Noise removal and detail enhancement. Unsupervised and supervised classification. - 8 h

Summer semester:

dr Bogumiła Mysłek-Laurikainen - Radioecology, natural radioactivity and radioactive pollution in environment; monitoring of radioactive contamination; nuclear power stations contribution to world energy consumption; radioactive waste policy; nuclear weapons tests; radioecology in future - 10 h

dr Ryszard Balcer - Physics of atmosphere – definitions of ecology, ecosystem and monitoring; geospheres; solar and terrestrial radiation; energy balance of Earth; instrumentation for solar radiation measurements, micrometeorological measurements; aerosols in atmosphere; clouds chemistry - 10 h

prof. dr hab. Ryszard Stolarski and dr hab. Zygmunt Kazimierczuk - Pollution of environment and protection mechanisms – organic pollution of water and soil; enzymatic decomposition of some mutagenic and cancerogenic agents; molecular foundations of heredity; molecular mechanisms of genetic reparation of damages caused by environmental pollution - 10 h.

Literature: Lecture notes available in the library of IFD.
Prerequisites:
Examination: Test examination.

***

Course: **316A Seminar on modern physics**	
Lecturer: **prof. dr hab. Andrzej Twardowski**	
Semester: **winter**	*Hours per week:* **2**
Code: **13.205316A**	*Credits:* **2,5**
Syllabus: The aim of the seminar is to present basic problems of the modern experimental and theoretical physics, with focus on the research currently in progress at Warsaw University. The seminar is designed as a series of 26 one-hour lectures given by scientists from different research groups. After the presentations students should recognise the activity at Faculty of Physics and the relation of this activity to the worldwide research. This way the seminar should help the students of the third year to make the decision concerning their specialisation in physics.	
Literature:	
Prerequisites:	
Examination: Pass for students who attend seminars.	

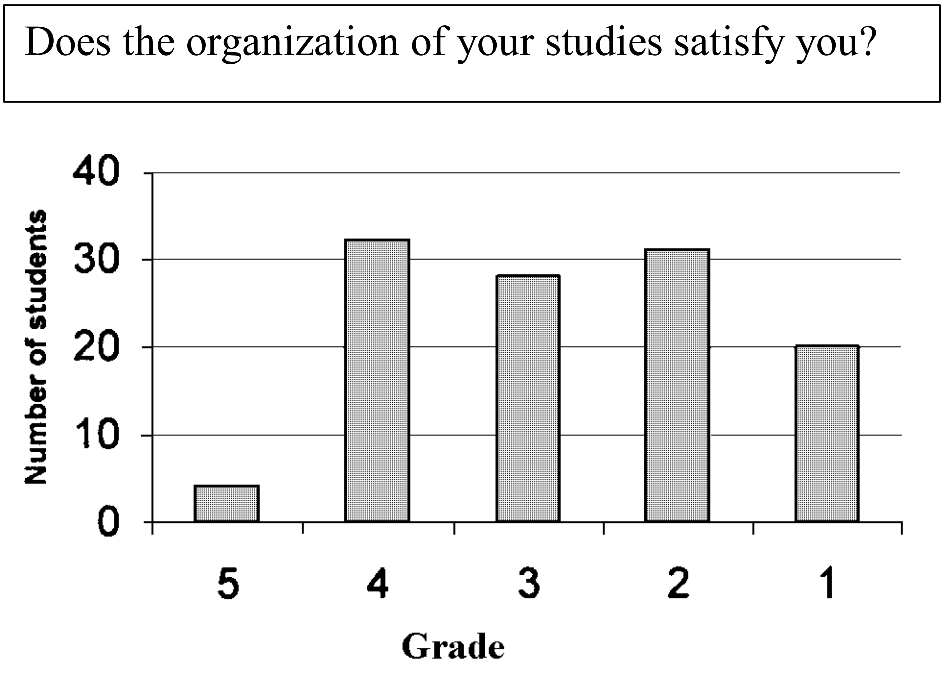
Annex C: Quality Assurance Mechanisms

Students' activities and teaching quality report

Prepared by the Students' Council at the Faculty of Physics

One of the most important tools for evaluating quality at the Faculty of Physics of the Warsaw University is a questionnaire given to majority of student at the end of a term. The poll ask for answers to the questions concerning the way, in which the specific lectures, coursework or students laboratory is leaded. It includes a place for student's personal opinion, also. The poll helps to improve quality of specific lectures and correctly assign scientific employees to educational activities. Results are discussed on Faculty's Council and published in the scientific library of the Faculty. The best rated educators receive a financial prize. Every year the set of the poll questions is discussed and improved.

In academic year 2001/2002, Student's Council of Faculty of Physics has leaded its own question form among students, concerning organization of studies. Among all of the questions, following were chosen as most important:



Does the organization of your studies satisfy you?

The answers to this question shows, that very few students rate the organization of studies as very good. Almost the same number of students rates studies as good (4) or bad (1). Answers to the more specific questions show reasons of these marks:

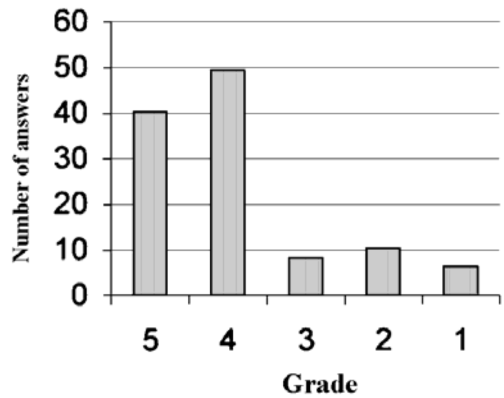
- inconvenient localization of the foreign language courses,

- long distances between places where specific lectures are given and poor adjustment of daily lectures plan,
- poor adjustment of the dean’s office working hours to students' time possibilities.

Positive aspects of organization of studies at the Faculty of Physics are:

- sufficient number of sites in computer laboratories,
- good outfit of scientific libraries.

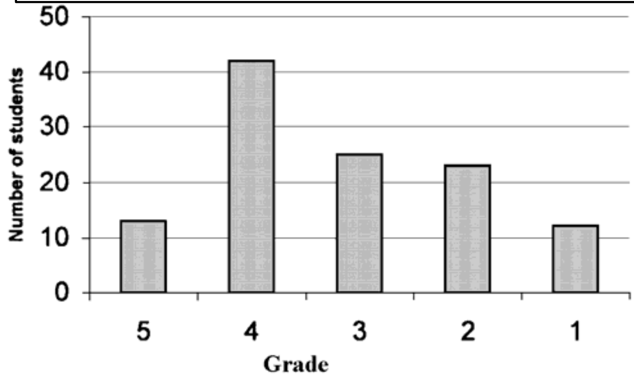
Does the teaching level on your faculty satisfy you?



Does the teaching level on your faculty satisfy you?

According to the figure, a great majority of students rate teaching level in Faculty of Physics as good or very good. Reasons of these results are due to the good preparation of lectures, which makes very difficult topics understandable to the students.

Is your vision of studies at the Faculty of Physics consistent with reality?



Is your vision of studies at the Faculty of Physics consistent with reality?

According to the figure, vision of studies at the Faculty of Physics of most students is consistent with reality, but there are many, who do not have a strong opinion, and the part of students, whose opinion is negative is small.

This question form was given to about 10% of the students population.
An important feature at the Faculty of Physics is the activity of Students' Council and scientific students’ clubs.

Students’ Council represents the students' population (and opinion) at the Faculty's authorities. Members of the council have their places in Faculty's Council and Program Council, and represent students in Warsaw University Students' Parliament. Last two years of Students' Council activities have increased an activity of scientific clubs, brought improvement in contacts with scientific employees (introduction of more able students' years protectors), and increase of students' interest in promoting physics among society.

In summary, in most students' opinion, studies in Faculty of Physics are difficult, but achieving a grade in physics gives huge satisfaction and universal, unordinary abilities. An important thing is that despite difficult economical situation in Poland, there is no unemployment among graduates of our faculty.

Dean's poll

Typical questions in the pool concerning lectures

The questions are group into two parts. First part (points 1-4 and 10) please mark the most suitable answer. In points 5-9 please mark by X the proper grade in the scale 0-5 (5 is the highest).

1.	***Choose the best qualification describing the subject of the lecture*:** easy, difficult, very difficult						
2.	***Choose the qualifications (or give your own) that in your opinion characterise the way of lecturing (you can mark more than one)*:** incomprehensible, too fast, too tedious, interesting, chaotic, to many transparencies/slides, to few transparencies/slides, easy to make notes, difficult to make notes, ...						
3.	***How often you study the subject by yourself?*** never, only before colloquia and exam, from time to time, often, systematically.						
4.	***From what materials are you learning?*** Own notes, notes of other students, notes prepared by the lecturer, textbooks.						
5.	*How well does the previously obtained knowledge (high school, other lectures) gives you a background for this subject?*	*0*	*1*	*2*	*3*	*4*	*5*
6.	*Please rate the capability and commitment of the lecturer to give this lecture.*	*0*	*1*	*2*	*3*	*4*	*5*
7.	*Are the conditions for being classed and for the exam clearly formulated?*	*0*	*1*	*2*	*3*	*4*	*5*
8.	*What is your rating of the lectures as regards lecture ?*	*0*	*1*	*2*	*3*	*4*	*5*
9.	*What is your rating of the person of preparing the experiments for the lecture ?*	*0*	*1*	*2*	*3*	*4*	*5*
10.	***How often have you attend the lecture (mark proper answer) ?*** never, seldom, time to time, often, always.						

Attention: Please write your personal opinion and comments on the back side.
(This information is only for the dean's and lecturer's use)