



**UNIVERSITY OF RIJEKA
DEPARTMENT OF PHYSICS
and
FACULTY OF ENGINEERING**

**UNIVERSITY GRADUATE STUDY PROGRAM
ENGINEERING AND PHYSICS OF MATERIALS**

Proposal

Rijeka, March 2010.

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Attachment: Written permission for lecturers from other institutions.

1. INTRODUCTION

1.1. Grounds for proposition of this program and the evaluation of its purpose

Exponential growth of science achievements in the fields of natural sciences and technologies requires a long-term and quality education of experts with a wide and diverse range of knowledge and skills. Accordingly, we propose the two-year university postgraduate program

Engineering and Physics of Materials

based on the multidisciplinary activity engaged in the application of basic sciences and engineering to understanding the behavior of materials, their development and applications. The modern society demand for a rapid and diverse succession of new, specialized materials has resulted in a concentrated, systematic approach to materials research and education of experts in the field of materials science and engineering. In the past, specialized materials were developed through a trial-and-error process. Today, this approach has been replaced with design of innovative materials for specific application in which the tools and expertise of scientists are being combined with those of engineers, resulting in productive cooperation in both applied and theoretical areas.

Materials science is an exciting sector, aiming to the development of new materials or changing the properties of existing ones for more efficient use or broader applications. Today, it is almost impossible to create a new generation of advanced materials, such as semiconductors, superconductors, polymers or ceramics, or even advanced devices, such as lasers, micromotors, or biological tissue replacements, without understanding and controlling the characteristics of materials, their surfaces and interfaces from atomic to macroscopic level. And this is the domain of engineering and physics of materials.

Engineering and physics of materials is a rapidly expanding area, focused on meeting the world's need for 21st century materials for use in sectors as diverse as energy, transportation, electronics, medicine or construction and civil engineering. Most American universities have developed programs in materials science or science and engineering of materials, and the same trend is present at a great number of European universities (for example, such programs exist at around twenty universities in Great Britain alone), strongly supporting the development of economy based on new scientific knowledge and advances in science. The host departments for such multidisciplinary programs are usually departments of natural sciences, engineering or materials science.

The multidisciplinary approach to materials science opens a possibility to all students having undergraduate degrees from a diversity of programs, including physics (or physics combined with some other fields), chemistry, materials science, engineering (from mechanical and electrical engineering to civil or naval engineering), biological sciences, as well as computer science or polytechnics. As the proposed program is the first of this kind in Croatia, it could possibly attract students from other Croatian universities, following the recommended trends in students mobility.

The university graduate program Engineering and Physics of Materials is proposed as a joint venture between the Department of Physics and the Faculty of Engineering of the University of Rijeka. This combination of program hosts ensures the integration of fundamental knowledge from physics and other sciences with the most recent advancement in engineering, analysis and processing of materials. Students graduating from this program will be trained to develop new technologies and materials and find their applications and will be able to find employment in academia or government, industry, research centers and institutes, or to continue with postgraduate studies. In all of Europe, including Croatia, there is already a significant shortage of

experts in the field of science and engineering of materials in industries involved in materials production, design, processing or application, such as car and airplane industries, shipbuilding, civil engineering and medical or semiconductor industry.

As a typical interdisciplinary program, the university graduate program Engineering and Physics of Materials is based mostly on the existing skills, expertise and knowledge of the teaching and research staff at the University of Rijeka, and, in a smaller extent, on the collaboration with the Institute of Physics in Zagreb.

1.2. Past experience of the host institutions in the implementation of similar programs

The foundation of the Faculty of Mechanical Engineering in Rijeka in 1960 with the aim to satisfy the requirements of the industry of Rijeka and the whole region can be regarded as the initiation of systematic engineering education and scientific research, particularly in the field of mechanical engineering and naval architecture. At first, only graduate engineers of Mechanical Engineering were educated. However, in 1969/70 the education of the graduate engineers of Naval Architecture has also started and the Faculty was then renamed into Mechanical Engineering & Naval Architecture Faculty in Rijeka. The opening of the study for graduate Civil Engineers in 1971/72 resulted in the establishment of the independent Faculty of Civil Engineering in the year 1976 and the Faculty was renamed into the Technical Faculty Rijeka. Finally, since 1994 the Faculty has been functioning under the name University of Rijeka - the Faculty of Engineering. In 1999/00 the education of graduate engineers in Electrical Engineering commenced, while in 2008/09 a new university undergraduate program Computer Science has been introduced. To enable the graduate engineers of Mechanical Engineering and Naval Architecture to deepen their acquired knowledge and scientific permanent education, the post graduate scientific study was inaugurated in 1971/72. Today, the Faculty of Engineering numbers 88 permanent employees at scientific, teaching and associate levels, 35 junior researchers, 46 associate lecturers and assistants, and 51 administrative employees and technical personnel.

Nowadays, the Faculty of Engineering is offering university undergraduate and university graduate studies of mechanical and electrical engineering and naval architecture, with curriculum fully adjusted to the Bologna Declaration. The university graduate program Engineering and Physics of Materials is coordinated with the Institute for Materials which is one of the Institutes established within the Faculty of Engineering with the aim to conduct all teaching and research activities of the Faculty in the field of materials science and engineering. Teaching activities are focused on courses from the module Engineering of Materials offered in the university graduate program Mechanical Engineering.

On the other hand, the study of physics at the University of Rijeka started in several higher-education institutions in 1953 (the two-year program at the Pedagogical College, the four-year programs at the Industrial Pedagogical College, the Faculty of Industrial Pedagogy, the Pedagogical Academy in Rijeka, Pula and Gospic and the Faculty of Pedagogy) with the aim to prepare students for the teaching profession. The four-year program in Mathematics and Physics started in the academic year 1964/65, following with the program in Physics and Technical Education in 1971/72 and Physics and Computer Science in 2004/05. The former Faculty of Pedagogy in Rijeka was also offering for several years, from 1979-1985, the combined program of Physics and Chemistry.

In 1988 the Faculty of Pedagogy in Rijeka changed its name into Faculty of Arts and Sciences. One of the founding members of the new Faculty was the Department of Physics. The Department of Physics organized the four-year graduate programs Mathematics and Physics and Physics and Computer science. Both programs were conducted in the form of lectures, seminars, practical work

and teaching practice, giving the students the qualification of high-school teachers of Mathematics and Physics or Physics and Computer Science. The teaching staff of the Department was also involved in teaching physics courses in other university programs, such as Physics and Polytechnics and Mathematics and Computer science, hosted at the Faculty of Arts and Sciences of the University of Rijeka by the Department of Polytechnic and the Department of Mathematics, respectively.

Following the recommendations of the Bologna declaration, the Department of Physics the Faculty of Arts and Sciences has started in 2005 the three-year undergraduate program in Physics, followed by the two-year graduate programs of Physics and Mathematics, Physics and Computer Science and Physics and Polytechnics. After completing the undergraduate studies of Physics (3 years), students are getting the degree of Bachelor of Physics, while at the end of the graduate program (5 years) they are getting the degree of Masters of Education in Physics and Mathematics, or Physics and Computer Science or Physics and Polytechnics.

In the education of students, the Department of Physics was giving special attention to demonstrational experiments and laboratory training, which is in accordance with contemporary methods of constructivist theory of studies of physics that enables better understanding of teaching contents and increases the level of knowledge while, at the same time, prepares student for the same methods of teaching in their future teaching profession. Students who have shown special predispositions and skills were involved in the scientific research with the possibility to enroll in some PhD programs at other Croatian Universities, a find employment academia or research institutes in Croatia or abroad.

In December 2007, the Senate of the University of Rijeka established the Department of Physics of the University of Rijeka, as an independent research and teaching University Department. All the programs and students from the Department of Physics of the Faculty of Arts and Sciences were transferred to the new University Department of Physics in April of 2008 when the old Department within the Faculty of Arts and Sciences was officially closed. At the same time, the new University Department of Physics was also entrusted with teaching of Physics courses in programs of all Faculties of the University of Rijeka and developing of teaching, research and professional curriculum in the field of Physics.

The Department of Physics of the University of Rijeka numbers 19 permanent employees at research, teaching and associate levels, 7 PhD students and 7 administrative employees and technical personnel.

1.3. Correlation with the modern scientific perceptions

The university graduate program Engineering and Physics of Materials focuses on understanding the relationships between the microstructure and the macroscopic properties of solids, as well as synthesis, processing, modification and characterization of materials. This includes a wide range of materials such as metals, polymers, ceramics or composite materials or semiconductors and magnetic materials. A wide choice of modules and courses offered in this program enables us to modernize the program in the future by integrating some new modules or courses following the new advances and knowledge in the field.

Modern fundamental and applied science is nowadays increasingly dependent on the multidisciplinary approach in solving problems and educating experts. The proposed program is multidisciplinary because it combines the knowledge of physical, structural, mechanical and electrical properties of materials from a range of natural sciences and engineering. It is multidisciplinary also in that it combines the theoretical and experimental capabilities of a variety of disciplines and applies them to the solution of complex scientific and engineering problems.

1.4. Compatibility with programs offered at other international universities

In most American and European universities we find programs of similar names, such as Materials Science or Materials Science and Engineering, with programs similar to the proposed program Engineering and Physics of Materials. All these programs are based on the multidisciplinary approach and courses drawn from several different Departments (most often Departments of Physics, Engineering or Chemistry). Special attention is always given to courses of fundamental physics, laboratory work and fundamentals of technology of materials. Mandatory and elective courses covering fundamentals offered in our two-year graduate program Engineering and Physics of Materials are similar to courses offered in Physics or Engineering programs at Universities of Rijeka, Zagreb, Split and Osijek, and also at several distinguished European or USA universities (for example, Manchester in Great Britain, Trieste in Italy or MIT in USA).

Mandatory and elective courses covering more specific problems in materials processing, characterization or applications, are very similar to those offered at most international universities, from Europe and the USA to Australia.

1.5. Potential partners outside the academia

There is already a great demand in industry, academia and government in the Rijeka region, as well as in Croatia or Europe, for graduates and experts from the fields of Materials Science and Engineering which will graduate from our program Engineering and Physics of Materials. The Engineering and Physics of Materials program provides a multi-disciplinary foundation from which graduates can develop careers in a range of engineering and scientific roles in industry, academia, or government. Therefore, these institutions are potential partners of this program.

All branches of Croatian economy involved into design, production, processing or application of materials, or having R&D laboratories (it is hard to imagine nowadays any industry not involved into materials science, as materials design, processing and applications is important for industries such as car and airplane industries, shipbuilding, civil engineering or medical, pharmacology or semiconductor industry) are potential partners of the proposed program.

1.6. Openness to student mobility

The proposed program is in accordance with provisions of Croatian law regulating activities in the field of science and higher education (NN no. 123/2003(+), in accordance with the ECTS criteria (European Credit Transfer System) published in the University journal, vol. XLVI, 2000, and in accordance with The Statute of the University of Rijeka.

All courses within the two-year graduate program Engineering and Physics of Materials are planned as one-semester courses which enables dynamic exchange of contents as well as mobility of students and student exchange programs at any stage of their studies, with other Croatia or European Universities, upon completion of all chosen courses. An exceptional potential for student exchange program is opened by offering our students a wide range of elective courses.

In addition, the proposed program is designed for students having undergraduate degrees from a diversity of science and engineering disciplines, encouraging, therefore, student mobility within the University of Rijeka or other universities.

1.7. Other relevant information

The graduate university program Engineering and Physics of Materials has been planned and accomplished as a joint effort of the Department of Physics of the University of Rijeka and the Faculty of Engineering of the University of Rijeka, with the Institute of Physics from Zagreb as an external collaborator. The latter institution is in charge of three courses in our program and also provides several experimental facilities for experimental work, projects or thesis work for our students.

Multidisciplinary and interdisciplinary character of our program is also evident from the joint effort of the research and teaching staff from different Departments or Faculties within the University of Rijeka and respectable researchers from some other Croatian institutions. In this way, we are making a significant contribution towards the rapid and harmonic development of the University of Rijeka, but also towards economical and social development of Rijeka and surrounding region.

2. GENERAL PART

2.1. Program Title

The Graduate University Program Engineering and Physics of Materials.

2.2. Program Holders and Performers

Interdisciplinary university program Engineering and Physics of Materials is organized by two institutions: The Department of Physics of the University of Rijeka and The Faculty of Engineering of the University of Rijeka. Both institutions are equal performers of the program, but Program Holder is:

University of Rijeka
Department of Physics
Slavka Krautzeka bb
51000 Rijeka

2.3. Scientific Area and Field

Scientific areas: Natural Sciences and Engineering.

Fields: Physics, Materials Science

2.4. Program Duration

Two years (4 semesters).

2.5. Academic Title

Master of Engineering and Physics of Materials.

2.6. Enrolment Conditions

Enrolment is open to all students from Universities of Rijeka, Zagreb, Split or Osijek having undergraduate degree from a program containing courses on fundamentals of physics and mathematics, i.e. students with the Bachelor degree in Physics or Physics combined with any other field, Chemistry, Polytechnics or Computer Science, or the Bachelor degree of any engineering field.

2.7. Profile of the Academic Degree

The Graduate University Program Engineering and Physics of Materials provides the fundamental knowledge and competences in the fields of physics and materials science and engineering, focused on understanding of properties, synthesis, processing, modification and application of materials. This knowledge and competences will enable the graduated students to find employment in industry, research centers and institutes which are involved in development of new technologies or the application of new materials, or as research scientists in academic institutions, experts in government organizations or to continue with postgraduate studies.

2.8. General and Specific Competences

The knowledge and competences provided by the Graduate University Program Engineering and Physics of Materials include:

1. Obtaining the fundamental knowledge of science and technology important for understanding the properties of materials.
2. Ability to develop and apply that knowledge in order to synthesize and process different materials, or design or change materials properties.
3. Recognition of fundamental properties of materials and ability to choose analytical technique or design and conduct experiments for the characterization of materials and to analyze and interpret experimental results.
4. Ability to identify materials-related problems and formulate plans to solve such problems.
5. Ability to design optimal materials and processes for a specific application and to produce them.
6. Development of personal research and analytical skills by undertaking small research projects and thesis work in real experimental environment.

2.9. Level of Competence for Continuation of Studies

After completing this program, the graduated students with the degree of Master of Engineering and Physics of Materials will be able to continue their studies at any university PhD program compatible to materials science, physics, and environmental science or engineering.

3. CURRICULUM DETAILS

3.1. The List of Mandatory and Elective Courses with lesson times and ECTS Credits

Tables contain following abbreviations:

- L - Lectures
- S - Seminar
- AE - Auditory Exercises
- LE - Laboratory Exercises
- CE - Construction Exercises

| 1. Semester | | | | | | | |
|--|----------------|---|----|----|----|--------------|-----------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Theoretical Physics and Applications I | 2 | 1 | 1 | 0 | 0 | 4 | 6 |
| Statistical Physics | 2 | 0 | 1 | 0 | 0 | 3 | 5 |
| Metal Materials | 2 | 0 | 0 | 1 | 0 | 3 | 5 |
| Non-Metallic Materials | 2 | 0 | 0 | 1 | 0 | 3 | 5 |
| Elective Course I | | | | | | 3 | 4 |
| Elective Course II | | | | | | 4 | 5 |
| TOTAL | | | | | | 20 | 30 |

| Elective Course I | | | | | | | |
|--|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| ⁽¹⁾ Fundamentals of Engineering Design | 2 | 0 | 0 | 0 | 1 | 3 | 4 |
| ⁽²⁾ Physics Laboratory | 0 | 0 | 0 | 3 | 0 | 3 | 4 |
| ⁽¹⁾ For students with undergraduate degree in science. ⁽²⁾ For students with undergraduate degree in engineering. | | | | | | | |

| Elective Course II | | | | | | | |
|---------------------------------------|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Computational Physics | 2 | 0 | 2 | 0 | 0 | 4 | 5 |
| Measurements in Physics | 2 | 1 | 1 | 0 | 0 | 4 | 5 |
| <i>Only one course to be elected.</i> | | | | | | | |

Tables contain following abbreviations:

- L - Lectures
- S - Seminar
- AE - Auditory Exercises
- LE - Laboratory Exercises
- CE - Construction Exercises

| 2. Semester | | | | | | | |
|---|----------------|---|----|----|----|--------------|-----------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Theoretical Physics and Applications II | 2 | 1 | 0 | 0 | 0 | 3 | 5 |
| Solid State Physics | 2 | 1 | 1 | 0 | 0 | 4 | 6 |
| Materials Protection | 2 | 0 | 1 | 1 | 0 | 4 | 5 |
| Organization of Production | 2 | 0 | 2 | 0 | 0 | 4 | 5 |
| Elective Course III | | | | | | 4 | 5 |
| Elective Course IV | | | | | | 3 | 4 |
| TOTAL | | | | | | 22 | 30 |

| Elective Course III | | | | | | | |
|--|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| ⁽¹⁾ Manufacturing Technologies | 3 | 0 | 0 | 0 | 1 | 4 | 5 |
| ⁽²⁾ Experimental methods in physics | 2 | 1 | 1 | 0 | 0 | 4 | 5 |
| ⁽¹⁾ For students with undergraduate degree in science. ⁽²⁾ For students with undergraduate degree in engineering. | | | | | | | |

| Elective Course IV | | | | | | | |
|---------------------------------------|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Laboratory Project | 0 | 3 | 0 | 0 | 0 | 3 | 4 |
| Fracture Mechanics | 2 | 0 | 0 | 1 | 0 | 3 | 4 |
| Free Elective Course | | | | | | 3 | 4 |
| <i>Only one course to be elected.</i> | | | | | | | |

Tables contain following abbreviations:

L - Lectures

S - Seminar

AE - Auditory Exercises

LE - Laboratory Exercises

CE - Construction Exercises

| 3. Semester | | | | | | | |
|---|----------------|---|----|----|----|--------------|-----------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Physics of Materials I | 2 | 0 | 2 | 0 | 0 | 4 | 6 |
| Semiconductors: principles and applications | 2 | 1 | 1 | 0 | 0 | 4 | 6 |
| Mechanics of Materials | 2 | 0 | 1 | 1 | 0 | 4 | 5 |
| Testing of Materials | 2 | 0 | 1 | 1 | 0 | 4 | 4 |
| Elective Course V | | | | | | 4 | 5 |
| Free Elective Course | | | | | | 3 | 4 |
| TOTAL | | | | | | 23 | 30 |

| Elective Course V | | | | | | | |
|---------------------------------------|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Magnetic Materials and Applications | 2 | 1 | 1 | 0 | 0 | 4 | 5 |
| Nanosciences and Nanotechnologies | 2 | 1 | 1 | 0 | 0 | 4 | 5 |
| <i>Only one course to be elected.</i> | | | | | | | |

Tables contain following abbreviations:

- L - Lectures
- S - Seminar
- AE - Auditory Exercises
- LE - Laboratory Exercises
- CE - Construction Exercises

| 4. Semester | | | | | | | |
|--|----------------|---|----|----|----|--------------|-----------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Physics of Materials II | 2 | 0 | 2 | 0 | 0 | 4 | 6 |
| Heat Treatment of Metals and Surface Engineering | 2 | 0 | 1 | 1 | 0 | 4 | 5 |
| Elective Course VI | | | | | | 4 | 5 |
| Elective Course VII | | | | | | 3 | 5 |
| Master Thesis Seminar | 0 | 6 | 0 | 0 | 0 | 6 | 9 |
| TOTAL | | | | | | 21 | 30 |

| Elective Course VI | | | | | | | |
|---------------------------------------|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Spintronics | 2 | 1 | 1 | 0 | 0 | 4 | 5 |
| Micro-Systems Technologies | 2 | 0 | 2 | 0 | 0 | 4 | 5 |
| <i>Only one course to be elected.</i> | | | | | | | |

| Elective Course VII | | | | | | | |
|---------------------------------------|----------------|---|----|----|----|--------------|------|
| Course Title | Hours per Week | | | | | | ECTS |
| | L | S | AE | LE | CE | L+S+AE+LE+CE | |
| Materials Selection | 2 | 0 | 0 | 1 | 0 | 3 | 5 |
| Casting | 2 | 0 | 0 | 1 | 0 | 3 | 5 |
| Materials Characterization | 2 | 0 | 0 | 1 | 0 | 3 | 5 |
| <i>Only one course to be elected.</i> | | | | | | | |

| | | |
|--|---------------------|---------------------|
| TOTAL FOR UNIVERSITY GRADUATE STUDY OF ENGINEERING AND PHYSICS OF MATERIALS | Hours 86 | ECTS 120 |
|--|---------------------|---------------------|