



University of
Belgrade

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**Improvement of Product Development Studies in Serbia And
Bosnia and Herzegovina**

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Faculty of Mechanical
Engineering



Tempus

REPORT

**Education in the field of Industrial Product Development and Management of Product
Development & Innovation Management**

**UNIVERSITY OF BELGRADE
Faculty of Mechanical Engineering**

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INTRODUCTION

University of Belgrade (BU) is a higher education institution with the long tradition of technical sciences in the Western Balkan region. BU was formally established in 1863. but its origins reach back to 1808. BU consists of 31 Faculties, 11 Institutes, 8 Research Centers and University Library "Svetozar Markovic". The University of Belgrade and Faculties within it organize academic and professional studies based on accredited higher education study programmes which give students the opportunity to develop and apply their scientific, professional and artistic achievements. Faculties and Institutes of the University of Belgrade are well provided with the facilities and equipment necessary for the quality performing of all scientific and educational activities.

University of Belgrade realizes study programs on Bachelor, Master, PhD and Post-doc level, which are harmonized with the principles of Bologna declaration, with nearly 15.000 new students per year (academic studies degrees are described in details in Table 1.). Intensive capacity building for scientific research results in over 300 doctoral theses per year and as the largest learning community in this part of Europe, with 81,452 students and 2,615 academic and research staff, 1,672 papers on SCI, SSCI and AHCI lists, numerous publications and scientific and research projects, the University of Belgrade has unique responsibilities and opportunities toward the society.

No.	Academic study degree	Abbreviation	Total No. of study programs	Description
1.	Bachelor	B.Sc.	88	Undergraduate academic studies, lasting three to four years and granting, upon their completion, 180 to 240 ECTS points. A student who completes first degree academic studies with at least 180 ECTS points acquires the professional title of Bachelor of science. A student who completes first degree academic studies with at least 240 ECTS acquires the professional title of Bachelor with Honors.
2.	Master	M.Sc.	129	Master academic studies, lasting from one to two years and granting, upon their completion, 60 to 120 ECTS points. A student who completes these second degree academic studies acquires the academic title of Master of science.
3.	Doctoral	Ph.D.	66	Doctoral academic studies, lasting at least three years and granting, upon their completion, at least 180 ECTS points. A student who completes doctoral academic studies of third degree acquires the scientific title of a Doctor of Philosophy in their respective field: PhD, Dr. sci. or Dr. juris.

Table 1: *University of Belgrade - academic studies degrees and programs;*

The University of Belgrade provides training in traditional and some new emerging disciplines and its Faculties are divided into four groups, according to the disciplines they teach: Sciences and Mathematics, Technology and Engineering Sciences, Medical Sciences and Social Sciences and Humanities.

Courses and modules related to Product Development and Innovation Management are present on almost every technical Faculty of University of Belgrade (regarding to their area of expertise), but education in the field of Product Development in narrow sense (Industrial) is provided primarily on the Faculty of Mechanical Engineering.

1. BACHELOR DEGREE STUDIES

Bachelor degree studies at the Faculty of Mechanical Engineering lasts for 3 years (VI semesters) and in total there are 27 obligatory courses that all B.Sc. students have to pass. Among the obligatory courses there are 8 related to the Industrial Product Development and they represent the basis for future knowledge level improvements in the relevant scientific area. Overview of those courses with matching number of ECTS points is shown in Table 2.

ECTS points are assessed individually with methods of assessment varying according to the nature of the subject (most subjects combine continuous assessment, such as projects, lab work, orals and written examinations etc.).

No.	Course	Semester	Total No. of teaching hours per week (workshops and practical work included)	ECTS credits
1.	Constructive geometry and graphics	I	2	2
2.	Strength of materials	I	3	4
3.	Engineering graphics	II	5	6
4.	Engineering materials 1	II	2	2
5.	Machine elements 1	III	5	6
6.	Engineering materials 2	III	5	6
7.	Machine elements 2	IV	5	6
8.	Manufacturing technology	V	5	6

Table 2: *Obligatory courses related to Product Development from curriculum of University of Belgrade - Faculty of Mechanical Engineering*

In order to prepare future mechanical engineers for their careers, among the offered elective courses there are at least 3 directly related to Industrial Product Development (Table 3) - all held by General Machine Design Department members. The elective courses depend of personal interests of students, but increasing number of students who elect them each year testify about their awareness of latest trends in Mechanical Engineering science.

No.	Course	Semester	Total No. of teaching hours per week (workshops and practical work included)	ECTS credits
1.	Fundamentals of product development	III	3	4
2.	Fundamentals of machine design	IV	5	6
3.	Machine design	VI	5	6

Table 3: *Elective courses directly related to Product Development from curriculum of University of Belgrade - Faculty of Mechanical Engineering;*

It's important to mention that, beside listed B.Sc. elective courses, there are many more indirectly related to Industrial Product Development (each of them 6 ECTS credits worth), such as:

1. Shape modeling;
2. FEM Analysis;
3. Introduction to engineering simulations;
4. Design and testing of welded structures;
5. Machine elements failure analysis;
6. Fundamentals of steel structures;
7. CAD/CAM Systems;
8. Computer Graphics;
9. Computer simulation and artificial intelligence;
10. Production technology and metrology;
11. The Base of the Strength of Constructions;
12. Design of Machinery;

13. Engineering Drawing;
14. Engineering Graphics;
15. Mechanism Design;
16. ...

At the moment, there are no obligatory courses on B.Sc. degree studies directly related to Management of Product Development & Innovation Management, but there are at least 3 elective – listed in Table 4.

No.	Course	Semester	Total No. of teaching hours per week (workshops and practical work included)	ECTS credits
1.	Engineering economic analysis	III	5	6
2.	Introduction to Industrial Engineering	III	5	6
3.	Business Management	IV	5	6

Table 4: *Elective courses directly related to Management of Product Development & Innovation Management from curriculum of University of Belgrade - Faculty of Mechanical Engineering;*

All of the previously mentioned courses (teaching subjects) are held according to principles of Bologna declaration, which means that they are consisted of:

1. Lectures – theoretical education;
2. Workshops – examples and real-life technical problems solving;
3. Practical work – study visits, laboratory work etc.

There is a variety of teaching methods implemented, combining the traditional lectures with seminar teaching, team-based group projects and laboratory-based practical work in order to develop students analytical, presentation and communication skills. Theoretical education is supplemented with practical work and this knowledge is later implemented during praxis where real examples from industry are studied in details.

2. MASTER DEGREE STUDIES

Courses on Master degree studies at the Faculty of Mechanical Engineering lasts for 2 years (IV semesters) and they are grouped in twenty-one study modules, with 9 obligatory (relevant for module's narrow discipline) and 5 elective (students can choose them depending on their personal interests) courses per module. Similar to B.Sc. degree studies, there are many elective courses directly and indirectly related to the Industrial product development and management of Product Development & Innovation Management, but specialized trainings in these fields are provided mostly by two study modules:

- DESIGN IN MECHANICAL ENGINEERING;
- INDUSTRIAL ENGINEERING.

2.1 Master degree study module 'Design in Mechanical Engineering'

Study module 'Design in Mechanical Engineering' trains mechanical engineers of general orientation with additional skills of new technical (mechanical) system development (Engineering Design), technical system harmonization with market needs (Industrial Design), harmonization with human being needs and natural environment.

In this study module participation of several departments (General Machine Design, Production Engineering, Aerospace Engineering, Industrial Engineering, Material Handling, etc.), ensures the needed multidisciplinary approach for complex field of Industrial Product Development.

Within this study module, Engineering Design is combined with Industrial Design, and enriched by bionics, ergonomics, aesthetics, ecology etc. Machine systems, developed to provide function and user needs, are harmonized to human features, environmental and ecological needs.

Students enrolled on this study module have opportunity to perform numerous design activities such as Conceptual Design (generate ideas – brainstorming), Embodiment Design (design parameters definition, decision making, axiomatic and genetic methods, CAD shape modeling, FE methods application, simulations, etc.). Additional activities comprise transformation of biological principals to technical systems (bionics), harmonization to human features (ergonomics) and to environment (ecology). Aesthetic design is one of the main objectives which students can perform using CATIA software, 3D printing (rapid prototyping), 3D scanning, virtual reality etc.

List of obligatory courses, that every student attending the ‘Design in Mechanical Engineering’ study module has to pass, is shown in Table 5. (matching number of ECTS points included).

No.	Course	Semester	Total No. of teaching hours per week (workshops and practical work included)	ECTS credits
1.	Product aesthetic	I	5	6
2.	Axiomatic methods	I	5	6
3.	Ergonomic design	II	5	6
4.	Development of machine systems	II	5	6
5.	Methods for decision making	II	5	6
6.	Bionics in design	III	5	6
7.	Special methods in product development	III	5	6
8.	Design and ecology	III	5	6
9.	Skill praxis M – DUM	IV	5	6

Table 5: *Obligatory courses from curriculum of ‘Design in Mechanical Engineering’ study module;*



Pic. 1: *3D printing (rapid prototyping) performed by ‘Design in Mechanical Engineering’ study module’s students;*

2.2 Master degree study module 'Industrial engineering'

Firstly, 'Industrial Engineering' study module was concerned with improving the effectiveness of industrial operations using relatively simple time and motion studies and methods analysis. As industry became more complex, engineers also began to be involved in design of production facilities using plant layout procedures and in the development of quality and safety control techniques. With the dramatic advances in computer sciences, the industrial engineers were faced with larger and more complex management problems, which could be solved using the tools of operations research. Today, industrial engineers are employed in all types of industry to design, improve and install systems using the methods and procedures of man, machine and materials. Mostly, they are concerned with production, although the analytical fact finding approach used today is applicable to almost any business or service enterprise.

The study module curriculum is programmed to provide students with the skills required by modern industrial engineers, including analysis of Product Design and Development to determine the optimum manufacturing process, selection of equipment and design of layout, design and installation of systems for controlling production, inventory, resources, quality or cost, job design and methods improvement, design of material handling systems, manpower utilization and work measurement and operations research. In addition to disciplinary content, the study module also encourages students to attain expertise in the use of modern information technologies and take part in professional and extracurricular activities.

Altogether, the goal of this study module is to produce efficient industrial engineers with a high rate of technical ability, including practical as well as theoretical knowledge, in order to attain secure and responsible positions in competitive arena of industrial and service enterprise, especially in the field of management of Product Development & Innovation Management.

Obligatory courses included in 'Industrial Engineering' study module are shown in Table 6., with matching number of ECTS credits.

No.	Course	Semester	Total No. of teaching hours per week (workshops and practical work included)	ECTS credits
1.	Production management 2	I	5	6
2.	Quantitative methods	I	5	6
3.	Industrial logistics	II	5	6
4.	Ergonomic design	II	5	6
5.	Engineering economy (with PRM)	II	5	6
6.	Skill praxis M – IIE	III	5	6
7.	Operations research	III	5	6
8.	Fundamentals of database systems	III	5	6
9.	Industrial management	IV	5	6

Table 6: Obligatory courses from curriculum of 'Industrial Engineering' study module;



Pic. 2: Practical work held by 'Industrial Engineering' study module teaching staff members;

2.3 Master degree elective courses

As it was mentioned before, there are many elective courses held on Faculty of Mechanical Engineering Master degree studies, directly and indirectly related to the Industrial Product Development and Management of Product Development & Innovation Management. Each of these courses is 6 ECTS credits worth, lasting 5 teaching hours per week, during one semester (workshops and practical work included). Among others, by the relevance stands out:

1. Research & Development Methodology;
2. Analytic Methods for Engineering Design;
3. Technical and Technological Development and Innovation Activity;
4. Special methods for product development;
5. Design and Construction M;
6. Development of Machine Systems;
7. Methods of Optimization;
8. Modern Quality Approaches;
9. Project Management;
10. Project documentation;
11. Technical regulations and standards;
12. Designing software for mechanical engineers;
13. Experiments and simulations;
14. Finite element method – FEM;
15. Mechatronics systems;
16. Engineering materials 3;
17. ...

It's important to accent that all of the previously mentioned M.Sc. courses are held according to principles of Bologna declaration, which means that they are consisted of Lectures, Workshops and Practical work - already described in Chapter No. 1.

3. DOCTORAL DEGREE STUDIES

Ph.D. studies held at the Faculty of Mechanical Engineering lasts for three years, with 4 obligatory and 5 elective courses, which students have to choose in agreement with their mentors and which have to be closely related to their Ph.D. thesis theme. None of the obligatory courses is significantly related to the Industrial Product Development and Management of Product Development & Innovation Management, but among the elective ones, by the relevance stands out:

1. Product Development in Mechanical Engineering;
2. Engineering Design Methodology;
3. Industrial Design;
4. Selected Topics in Design and Construction – A, B;
5. Selected Topics in Machine Elements – A, B, V;
6. Methods of design, construction, calculation and optimization of the process, plant, equipment and machinery;
7. Methods of Optimization of Mechanical Systems;
8. Computer modeling and structure calculation;
9. Finite Elements Methods in Applications;
10. Numerical Structural Analysis;
11. Design of system mechatronics;
12. Mechatronics Systems and Adaptronics;
13. Modelling, optimization and forecasting in Industrial engineering;
14. Planning, Performing & Controlling Projects;
15. Software Tools for Project Management;
16. Engineering Management;

17. Technical Legislation - Directives and Standards;
18. Total Quality Management (TQM);

Same as B.Sc. and M.Sc. degree courses, all Ph.D. courses held at the Faculty of Mechanical Engineering are harmonized with the principles of Bologna declaration as described in Chapter 1.

CONCLUSION

Analysis of current state of education in the field of Product Development and Management of Product Development & Innovation Management (PDMPD&IM) at the University of Belgrade (Faculty of Mechanical Engineering) shows the following:

- Bachelor degree students have more than enough opportunities to learn fundamentals of PDMPD&IM, but highly specialized trainings in this fields are provided later – on Master degree modules and courses;
- Relevant Master degree study modules include almost the same courses like corresponding modules of the Karlsruhe Institute of Technology, and cover all topics important for students future successful work in the PDMPD&IM;
- There are no obligatory courses on Doctoral degree studies related to the PDMPD&IM, but among elective courses there are many – among which Ph.D. students can choose those that suits them best for Ph.D. thesis writing and future professional developments;
- There are maybe too many elective courses on B.Sc., M.Sc. and Ph.D. degree studies closely related to the PDMPD&IM – which may lead to confusion, but they are the main reason why chance that any student will leave University without at least basic knowledge about PDMPD&IM is minimized;
- All analyzed courses are well harmonized with the principles of Bologna declaration and they promote the importance of PDMPD&IM for future development of technical sciences. They also integrate both theoretical and practical knowledge in order to make students of the University of Belgrade more competitive on world-wide Labor market;
- However, some of the analyzed courses could be additionally improved (especially those held by staff members of relevant General Machine Design Department), by implementing new teaching methodologies, new teaching materials (handbooks, power-point presentations etc.), new workshops, new lectures (with latest trends in relevant scientific areas discussed) etc.