STANDARDS AND INSTRUCTIONS FOR ACCREDITATION OF 1ST AND 2ND DEGREE STUDY PROGRAMS

Additional standards for study programs carried out in a foreign language, for joint study programs, for interdisciplinary/multidisciplinary/transdisciplinary (IMT) study programs, for distance learning programs and for studies carried out in another higher education institution.

INTRODUCTORY TABLE

Name of the study program:	**Advanced data analytics**
Higher education institution responsible for carrying out the program:	**University of Belgrade**
Educational - scientific/educational-artistic field:	**IMT studies**
Scientific, professional or artistic area:	**Computer science, Mathematics (IMT studies)**
Study level and type:	**Master academic studies**
Total number of ECTS credits:	**90**
Degree title:	**Master of data analysis**
Duration of studies:	**3 semesters**
The first year in which the program was carried out:	
The first year in which the program will be carried out (for new programs):	**2021/2022**
The number of students currently enrolled in this program:	
The planned number of students to be enrolled in this program:	**25**
The date the program was accepted by the governing body (name the body):	**12.06.2019. Senate of the University of Belgrade (Official decision)**
The language the program is to be carried out in:	**Serbian and English**
The year the program was accredited:	
Web address of the website/web page containing data about the program:	**https://www.ada.ac.rs/sp-ubg/**

Standard 0. Introduction

The graduate study program (Master study program) **Advanced Data Analytics** should be the main result of the participation of the University of Belgrade in the international project Advanced Data Analytics in Business, project no. EACEA 598829-EPP-1-2018-1-RS-EPPKA2-CBHE-JP, funded by the European Commission under the Erasmus + program.

The program focuses on a broad study area of quantitative sciences (mathematics, statistics, computing, information sciences, or a combination of some of these fields), stressing integration of these areas in analyzing different kinds of data and large volumes of data. Hence to enroll in this study program, the students who have completed undergraduate studies after the Law of Higher Education has become effective must have earned 240 ECTS credits, or have completed integrated studies (min. 300 ECTS), out of which at least 15 ECTS credits in mathematics, statistics and programming. The students who have completed undergraduate studies before the Law of Higher Education has become effective must have passed at least one exam in each of the following three topic areas: mathematics, statistics, and programming. It is also understood that students already have a basic experience with using computer technology and the Internet in representing, discovering, analyzing, visualizing and manipulating data. Through the graduate study program **Advanced Data Analytics**, students will be introduced to some of the more advanced tools and techniques used in data analysis, with application of these tools and techniques in selected domains. A wide variety of courses offered allows each student to focus on the domain(s) that they are most interested in – data analytics foundations, tools and technology, visualization techniques, programming and applications.

The need for such a study program stems from the fact that in Europe and also worldwide, as well as in Serbia and in the region, there is an increasing demand for professionals in various fields of data analysis who can conduct their activity in a way that involves the use of advanced database and data analytics technologies, especially when it comes to analyzing large volumes of data. Job offers, market trends, and trends in the economy, society, government bodies and other public institutions, clearly indicate this fact and do not require any further explanation.

A detailed insight into similar study programs at many universities in Europe and elsewhere indicates that three major pillars of modern data analytics are math / statistics, computer science (databases, data structures and algorithms, programming and artificial intelligence) and domain knowledge related to various phenomena in modern society. Therefore, the graduate study program **Advanced Data Analytics** offers a master degree from the University of Belgrade that guarantees the students have acquired relevant and sufficient knowledge from all these three intertwined areas of data analytics and are capable of conducting high-quality individual and team work in various data analytics problems. In addition, to complete the graduates' competences in data analytics, several courses present their topics putting them also in the context of collaboration and communication skills, legal regulations and ethical norms.

Standards

Standard 1: Structure of the study program

Due to the fact that the graduate study program **Advanced Data Analytics** is designed for students with different backgrounds, the program has in its offer several courses related to mathematical foundations of data analytics, as well as several courses related to computer science and computing tools used in data analytics. In addition, several courses cover application of data analytics in different domains, like social and medical sciences. Many of the courses offered present their topics putting them also in the context of collaboration and communication skills, legal regulations and ethical norms.

The total number of ECTS credits for this 3-semester study program is 90. A dedicated publication of the University of Belgrade (a set of regulations) clearly states the details (see Act 13 in the publication).

All courses in this study program are one-semester courses. The curriculum includes 23 elective courses, mandatory internship, qualification paper (term paper) and master thesis. Courses are worth 6-10 ECTS credits, the qualification paper 5 ECTS credits, internship 3 ECTS credits, and master thesis 10 ECTS credits.

The study program **Advanced Data Analytics** does not have modules, but a rich offer of elective courses allows students to select those courses that lead them towards the improvement of their knowledge in selected disciplines of quantitative sciences. The structure of this study program reflects the right balance between thematic fields of data analytics foundations and specific application areas.

There are three groups of elective courses in the study program **Advanced Data Analytics**. The first group covers mathematical and statistical foundations of data analytics, such as calculus, linear algebra, discrete structures and the like, for students who need to improve their background in mathematics (*Discrete structures*, *Mathematical Foundations of Data Analysis*, *Analytics and optimization*) and probability and statistics (*Introduction to statistical inference*, *Models of statistical learning*, *Introduction to complex networks theory*). The second group covers computing skills, tools and technologies for data analytics. These include programming, database technologies and working with large volumes of data (*Programming*, *Databases*, *Big data analytics*), different topics in artificial intelligence necessary for advanced data analytics (*Artificial intelligence / Machine learning*, *Neural networks and deep learning*), and specific topics and tools that help data analysts in working on practical problems (*Data visualization*, *Text mining* and *Social network analysis*). The third group is about applying data analytics skills, tools and techniques in different domains. The current focus is on social and life sciences, but the study program is open for extensions by elective courses covering other domains.

The teaching methods include the use of computers, the Internet and different software tools in most of the courses. Using open source software and free tools is a general orientation in this study program. All labs are held in computer classrooms, and most materials are available to the students on local computer networks or on the Internet.

In chapter *Standard 5. Curriculum*, detailed information is given about the courses, as well as about the prerequisites for some courses.

Attachments for standard 1

Attachment 1.1 Institution publication (institution site – version in English: http://bg.ac.rs/en/index.php)

Standards

Standard 2: The study program purpose

The purpose of the graduate study program **Advanced Data Analytics** is specialization in data analytics, primarily for students who have already completed their BSc studies in a quantitative discipline, but also for students with backgrounds in other disciplines.

A need for this study program comes from a higher demand (world-wide, but also in Serbia and in the region) for experts in data analytics in different fields who can intensively use current data analytics technologies in their work. Job offers, marketplace flow, as well as trends in economy, society, public administration bodies, and other public institutions, undoubtedly point to that fact.

On the other hand, the dynamic development of new computing, database and Internet technologies make undergraduate studies insufficient for an appropriate response to the abovementioned marketplace and social needs. That is the reason why by this study program the University of Belgrade wants to offer its students knowledge and competence that are in accordance with the dynamics of job offers in the marketplace that demands interdisciplinary knowledge.

University of Belgrade has a very long tradition in scientific computing, as well as in different disciplines where data analytics is becoming a must, such as medical, life and social sciences. For many years, at various faculties of the University of Belgrade courses in all these disciplines have been offered on all levels of studies. Due to the students' increased interest in specialization in data analytics after graduating in different fields, this study program meets their needs by offering integrated/interdisciplinary knowledge necessary for advanced data analytics.

Along the same lines, important strategic objectives of the University of Belgrade include:

1. Responding to the students' demands. The University of Belgrade continues to provide timely response to educational demands of its students, and the graduate study program **Advanced Data Analytics** is an example of such a response.
2. Coherence and comprehensiveness of study programs. There *are* master study programs at different faculties of the University of Belgrade in which parts of data analytics are covered. However, these existing programs do not offer an integrated coverage of the field, so the students enrolled in these programs have relatively narrow frameworks for furthering their studies. **Advanced Data Analytics** largely broadens this perspective and covers both the foundations and practical applications of data analytics.
3. Following educational trends. University of Belgrade wants to follow not only a national, but also world trends in the offer of the educated profiles. The number of study programs in higher education institutions related to data analytics is constantly growing over the last years worldwide.
4. High educational standards. University of Belgrade has sufficient resources and staff to offer a high-quality interdisciplinary master study program related to data analytics.

Attachments for standard 2

Attachment 1.1 Institution publication (institution site – version in English: http://bg.ac.rs/en/index.php)

Standards

Standard 3: The objectives of the study program

The objectives of the graduate academic study program **Advanced Data Analytics** at the University of Belgrade are:

- Improvement of theoretical and practical knowledge of quantitative disciplines (primarily math and statistics) required for the students who want to conduct data analysis in solving practical problems;
- Deepening of knowledge in the field of data analytics and quantitative methods, as well as mastery

of necessary computing and programming skills as prerequisites for working on practical problems that involve data analytics;
- Enabling students to master a range of practical software tools related to programming, data analysis, data visualization and the like, and use them in working on practical problems;
- Providing practical experience in applying the above mentioned skillset and toolset in working on practical, real-world problems, both in the individual engagement and teamwork, by involving students in current and new practical projects;
- Providing a foundation for work on research activities, as well as further education through relevant PhD study programs.

The program objectives are completely in compliance with strategic orientation and objectives of the University of Belgrade as an independent higher education institution:

- Development of creative abilities and mastery of specific practical skills necessary to perform professional activities, in this case those of an expert in data analytics;
- Training students to work in real-world environments, demonstrating a high-level expertise in working with large volumes of data being created in virtually all domains and activities; such students can contribute a great deal to modernization of work activities in different fields;
- Open higher education continuum, from undergraduate to PhD studies.

Attachments for standard 3

Attachment 1.1 Institution publication (institution site – version in English: http://bg.ac.rs/en/index.php)

Standards

Standard 4: Competencies of graduates

Students who have completed the master program **Advanced Data Analytics** at the University of Belgrade become competent in:

- independent work in analyzing datasets of different complexity in selected domains, with advanced use of current data analysis tools and technologies
- preparing, modifying, adapting and combining datasets for analysis, out of raw data produced from different applications and other sources
- involvement in various interdisciplinary working teams where data analysis skills in different disciplines and mastery of current data analysis tools and technologies are expected, not only in solving routine practical problems, but also in non-standard situations where creativity and research approach are required
- working with large sets of data

Subject-specific competencies of graduates include:

- ability to understand and analyze different datasets from the perspective of mathematical underpinnings of advanced data analysis (linear algebra, calculus, discrete mathematics, high-dimensional geometry, optimization, etc.)
- mastery of statistical underpinnings of advanced data analysis (data summaries, hypotheses testing, data variance, data correlation, probability and probability distribution functions, applying descriptive and inferential statistics to datasets, etc.)
- programming using state-of-the-art programming languages in data analytics
- skills in using advanced and appropriate data visualization techniques, as well as current software tools and technologies that enable creating rich data visualizations

The learning outcomes of the study program **Advanced Data Analytics** at the University of Belgrade include mastery of some of possible combinations of the following abilities:

- ability to use sound scientific approaches in analyzing different datasets (feature analysis, dataset preparation, data validation and verification, sampling, building predictive models, evaluating model

accuracy, etc.)
- ability to apply modern software environments, tools and Internet services in working with databases, data visualization, statistical data analysis etc. in different domains of social sciences, medicine, etc.
- extension of skill sets of professionals in different domains with experience with current data analytics tools and techniques
- well-developed communication and collaboration skills when working in interdisciplinary teams on different data analysis problems
- detailed understanding of data privacy, protection and security in data analysis in different domains, in terms of data protection from unauthorized usage, network attacks, etc.
- high-level understanding of legal regulations and frameworks and ethical standards that must be observed in solving data analytics problems

Attachment 4.1 Diploma supplement (English version)

Standards

Standard 5: Curriculum

The courses of the study program **Advanced Data Analytics** are developed around three major pillars of modern data analytics: **mathematical/statistical foundations**, **technological foundations**, and **applications**. The curriculum does not include required courses, but offers a wide range of elective courses around each of the three pillars, so that students can trace their learning paths more or less as desired.

Elective courses related to mathematical / statistical foundations (students choose 3 out of 6):

- Mathematical foundations of data analysis
- Discrete structures
- Analytics and optimization
- Introduction to statistical inference
- Models of statistical learning
- Introduction to complex networks theory

Elective courses related to mathematical / statistical foundations (students choose 3 out of 9):

- Programming
- Databases
- Big data analytics
- Data visualization
- Artificial Intelligence / Machine learning
- Neural networks and deep learning
- Text mining
- Social network analysis
- Introduction to time series analysis

Elective courses related to mathematical / statistical foundations (students choose 2 out of 8):

- Data analysis in fundamental and clinical medicine
- Data analysis in biological sciences
- Advanced data analysis in pharmaceutical research and development
- Practical analysis of noisy and uneven time series
- Big Data in space science and its analysis
- Advanced data analysis in social sciences
- Big Data in social sciences
- Analysis of international research datasets

The program also includes mandatory internship (capstone project / practicum) for students to get practical experience in working on data analytics projects, mandatory term paper (qualification paper), as well as mandatory master thesis.

NAT application electronic reports

By defending his/her master thesis, the candidate receives the academic title of *Master of Data Analysis*.

Tables and attachments for standard 5

Table 5.1.

Table 5.2 Course specification

Table 5.2a Course specification book – Advanced Data Analytics

Attachment 5.1 Course specification book (ready for publishing)

Standards

Standard 6: The study program quality, actuality and international character

The quality and actuality of the study program **Advanced Data Analytics** at the University of Belgrade are based on:

- *Recommendations of the world's most influential professional organizations in the field of data analytics*, such as AAi: Advanced Analytics Institute, International Institute for Analytics, Data Science Central, American Statistical Association (ASA), and the like (see https://www.kdnuggets.com/websites/societies.html). Special attention has been given to organizations focused on practitioners and practical projects (e.g., Data Science Central). Appendices 6.1-6.4 provide more details.
- *Compliance with similar programs.* This study program is very similar to master programs in data analytics at various universities in Europe and elsewhere in the world. Starting from the analytical approach to this topic published by experts from Park City Math Institute (https://www.stat.berkeley.edu/~nolan/Papers/Data.Science.Guidelines.16.9.25.pdf) and Stanford University (https://iriss.stanford.edu/css/certificate), some exemplary study programs in Europe for developing the **Advanced Data Analytics** program have been:
  - https://www.lse.ac.uk/study-at-lse/Graduate/degree-programmes-2021/MSc-Data-Science
  - https://www.epfl.ch/schools/ic/education/master/data-science/
  - http://bigdata.uniroma2.it/course-structure/

In addition, other study programs in data analytics offered by different universities in Europe (see https://www.kdnuggets.com/2017/12/best-masters-data-science-analytics-europe.html) and elsewhere in the world have also been taken into account, since they have a very rich offer in application-oriented courses and the **Advanced Data Analytics** program wanted to build on their experiences (see Appendices 6.1-6.4).

- *Orientation towards continuous improvement.* The content of each course has to be updated on a yearly basis, in order to follow the rapid development of the field.
- *Adjustment with European standards* in terms of enrolment conditions, continuity of study, the degree earned and the way of studying.

Standards

Standard 7: Admission/Enrolment

The admission/enrolment in a master study program at the University of Belgrade complies to a specific set of regulations, published officially by the University of Belgrade. See Act 13 in the publication. The admission/enrolment in the program **Advanced Data Analytics** complies with these regulations:

- applicants/candidates can enroll in this study program if they have completed their 4-year undergraduate studies and haveearned240 ECTS credits, or have completed their 4-year undergraduate studies before the Law of Higher Education has become effective
- applicants/candidates can also enroll in this study program if they have completed 300-ECTS integrated studies, or have completed master studies and have earned minimum 300 ECTS

These candidates must have earned at least 15 ECTS in mathematics, statistics and programming, or must have passed in their previous studies at least one exam in each of the following fields: mathematics, statistics and programming. Each candidate/applicant must have a good command of English, regardless of whether they apply for studying in English or in Serbian.

With regard to the real capacity of the University of Belgrade, it has been decided that, in order to provide high-quality teaching, 25 students per year should be enrolled in the study program **Advanced Data Analytics**. It has been planned that those students enroll in September for the next academic year.

The process of enrolment is conducted by the Program Council of the **Advanced Data Analytics** study program that includes teachers participating in the study program. The enrolment of candidates in the first year of the studies is conducted according to the public announcement (call for applications) published after an appropriate decision of the Senate of the University of Belgrade.

The students do not take a qualification exam. The ranking of the candidates to enroll in the first year of study of the **Advanced Data Analytics** study program is based on the candidates' GPA (achieved during the previous studies), the time they took to complete the previous studies, and possible research results they have achieved. The maximum number of enrollees in the first year of the study program in each generation of students is 25.

Standards

Standard 8: Assessment and progress of students

General principles of the assessment system of the study program **Advanced Data Analytics** at the graduate academic studies at the University of Belgrade include:

- *Point-based assessment and grading*. All students' activities in a course are graded with a certain number of points (see below). The maximum total number of points that can be earned for a course is 100.
- *Continuous assessment*. Due to the small group of students (25), observation of the continuity of work of each individual student in each course is assumed. The students are required to present evidence of their work regularly in discussions with the teachers (individually or in small groups). This way, each student can attain up to 10 points (out of max 100 points for each course). In addition, for each course there is a possibility to organize lab tests and/or projects arbitrarily (the students can take two lab tests or they can do two projects, individually or in groups). One lab test / project can bring up to 15 points.

- *Progress assessment*. Personal commitment and initiative are assessed with special attention, which is evaluated by the progress "gradient". The students who progress quickly and are more committed to group projects can achieve more points. The maximum number of points that can be achieved in this way is 10.
- *Assessment of practical work*. High quality of a student's practical individual work (assignments, individual projects) can bring the student maximum 30 points.
- *Final exam*. Final exam brings maximum 30 points.
- *Assessment of the students' research activities*. The maximum number of points that can be earned through all these previous items is 100. Students' research activities are not mandatory, but if a student expresses research interests, preferences, or potentials by taking part in such activities and achieving appropriate research results (e.g. a research publication) it can compensate for maximum 10 points lacking from previous items.
- *Assessment of the students' independent practical activities* (outside the compulsory scope that has been planned for the course). None of these activities are compulsory, but they can also compensate for a maximum of 10 points lacking from previous items, much like students' research activities.
- *Calculation of the final grade*. A student can earn the maximum of 100 points through all these described activities. It is necessary to earn at least 51 points in total to pass the exam. For 51-60 points earned, the grade 6 is assigned, for 61-70 points the grade is 7, for 71-80 points the grade is 8, for 81-90 points the grade is 9, and for 91-100 points the grade is 10 (the highest grade).
- *Internship, the compulsory qualification paper (term paper) and master thesis*. The master thesis has to be based on a practical data analytics project. The qualification paper and the master thesis, together with the mandatory internship, bring the total of 18 ECTS credits.

In addition to these general principles, assessment of each course has its own specific features (see individual course descriptions, Standard 5).

Standards

Standard 9: Teaching staff

Teachers with necessary academic and professional qualifications from several faculties of the University of Belgrade participate in the implementation of the graduate study program **Advanced Data Analytics** (Faculty of Philosophy (5 teachers), Faculty of Mathematics (4), Faculty of Biology (2), Faculty of Organizational Sciences (23), Faculty of Dentistry (2) and Faculty of Pharmacy (6)). In addition, researchers from institutes belonging to the University of Belgrade also participate in teaching in this study program ("Mihailo Pupin" Institute (3), Institute of Physics (3), INEP Institute for Application for Nuclear Energy (1) and Institute for Multidisciplinary Research (1)). Their qualifications can be verified by examining their competence sheets (the *Book of teachers*), Standard 9, and on the Websites of the faculties they are employed with. All teachers in this study program are involved in national and international research projects.

The number of teachers corresponds to the requirements of the study program. No teacher has a total maximum workload of 180 hours of active teaching per year (6 hours per week).

The percentage of teachers participating in this study program as full-time employees of the University of Belgrade, compared to the total number of teachers in this study program is 100%. Research and professional competences of the teaching staff correspond to different fields, altogether covering the interdisciplinary field of data analytics.

Attachments and tables for standard 9

Table 9.1 and additionally the Book of teachers (version ready for publishing)

Table 9.1a – Book of teachers – Advanced Data Analytics

Standards

Standard 10: Resources and facilities

To run the study program **Advanced Data Analytics**, the University of Belgrade and its faculties whose teachers participate in this study program have provided:

- human resources (teachers and tutors) fully qualified to run this program
- lecture rooms, computer rooms, seminar rooms, library and reading rooms
- technical, infrastructural (the Internet, LCD projector), laboratory, computing, and other resources
- access to a number of digital libraries
- financial resources to run the study program (provided from the tuition fees and from occasional donations)
- contacts with industry, companies and other organizations to ensure appropriate internship for the students

Standards

Standard 11: Quality assurance

Quality assurance of the study program **Advanced Data Analytics** implies regular and systematic monitoring and improvement of all aspects of the program quality: curriculum, teaching, teachers, assessment, textbooks and recommended readings. Quality assurance is conducted periodically, in accordance with the *Law of Higher Education*. The active role of students and their evaluation of the program quality (courses, teachers) are provided.

The *Council for University Studies* (*Council for Multidisciplinary Graduate Studies*) and the *Center for Quality Assurance and Advances of Education* of the University of Belgrade monitor the quality of the study programs run at the University of Belgrade.

Standards

Standard 12: Studies in English
Master study program **Advanced Data Analytics** should be the main result of the participation of the University of Belgrade in the international project Advanced Data Analytics in Business, project no. EACEA 598829-EPP-1-2018-1-RS-EPPKA2-CBHE-JP, funded by the European Commission under the Erasmus + program. The project has indicated that the master program should be conducted in English. Expecting a large number of students to be from Serbia or from the region, the teachers who have worked on the program development acknowledge that it should be accredited for both Serbian and English. All teachers and associates who are engaged in this program have the appropriate competencies for teaching in English. For the teaching in English, faculties and institutes of the University of Belgrade participating in the study program provide hundreds of relevant library units in that language in their libraries. The University Library "Svetozar Markovic" has a very rich selection as well. More importantly, all these libraries have a subscription to many relevant international journals, as well as cooperation with many international library services on the Internet. Teaching material for students is provided by teachers involved in the program, both in Serbian and in English. Administration personnel that work with students are sufficiently trained to provide services in English. All public documents and administrative documents are issued in a bilingual form, in Serbian language in Cyrillic script and in English. When applying to study this program, students will be reminded that they are expected to demonstrate satisfactory language competencies in English, as well as how this will be verified. The total number of students in both languages is 25 per year.

Standards

Standard 13: Joint study program
This standard is not applicable in the case of the **Advanced Data Analytics** study program.

Standards

Standard 14: Interdisciplinary / Multidisciplinary / Transdisciplinary (IMT) study program
Master study program **Advanced Data Analytics** is a highly interdisciplinary program. As it can be seen in Standards 1-4, and especially in the list and content of the proposed courses (Standard 5), the areas studied in this study program belong to the fields of quantitative research (quantitative science, mathematics, statistics, operational research), engineering (computing, artificial intelligence), as well as social and medical sciences (most of the application-oriented courses in the program). All these areas are closely intertwined in modern data analysis, and

therefore in this study program, where most of the credits are earned in quantitative research and computing (over 70% of ECTS points in total).

The implementation of IMT study programs is defined in the Statute of the University of Belgrade. The implementation of these study programs is organized and monitored by the *Council for University Studies* (*Council for Multidisciplinary Graduate Studies*) and the *Council for IMT Studies*. The implementation of such programs always involves teachers from various fields of professional work and from several faculties of the University of Belgrade.

The documentation submitted for the accreditation of the study program **Advanced Data Analytics** includes presentation sheets of all teachers, clearly showing their competencies in the various fields mentioned, as well as their total workload in all already accredited study programs in Serbia in accordance with Standard 9. The consent of the Teachers Councils of the faculties whose teachers are involved with this study program is also attached.

The diploma and diploma supplement of graduates from this study program shall be signed by the Head of the Council for IMT studies and by the Rector of the University of Belgrade.

The proposed academic title of students who complete this study program is Master of Data Analysis.

Standards

Standard 15: Distance learning

Distance learning is not foreseen in the study program **Advanced Data Analytics** at the University of Belgrade, since the program is planned for teaching in the classical way. However, if necessary, the entire program can be implemented online. The teachers and the entire University of Belgrade are completely ready for such a way of working after the COVID-19 virus pandemic.

Standards

Standard 16: Studies in a higher education unit without the status of a legal entity outside the headquarters of the institution

This standard is not applicable in the case of the **Advanced Data Analytics** study program.

Standards