University of Kragujevac
Faculty of Engineering

THE BOOK OF COURSES ON DOCTORAL STUDIES INDUSTRIAL ENGINEERING AND ENGINEERING MANAGEMENT

THE SCHOOL YEAR 2018/2019

The content

Scientific field: INDUSTRIAL ENGINEERING AND ENGINEERING MANAGEMENT

1.	IIIM101	The methods of artificial intelligence in engineering
2.	IIIM102	Integrated management system (IMS)
3.	IIIM103	Analysis and design of Information Systems
4.	IIIM104	Measurement and performance management of enterprise
5.	IIIM105	Advanced methods and control tools of industrial processes
6.	IIIM106	Advanced maintenance engineering
7.	IIIM107	Business intelligence
8.	IIIM108	Management system of occupational of health and safety
9.	IIIM109	Digital Manufacturing
10.	IIIM110	Computational Intelligence in Engineering
11.	IIIM111	Computer integrated enterprises and manufacturing
12.	IIIM112	The methods of artificial intelligence in management
13.	IIIM113	Business models of enterprises
14.	IIIM114	Modeling and optimization in the field of energy and environment
15.	IIIM115	Energy management
16.	IIIM116	Theory and techniques of experiment
17.	IIIM117	Product design optimization

Study research

1.	DSIR1	Laboratory, research, publishing - Independent Research Work - overview of the results in the scientific field
2.	DSIR2	Laboratory, research, publishing - Independent Research Work – systematization of theoretical range
3.	DSIR3	Laboratory, research, publishing - Independent Research Work

Scientific field: INDUSTRIAL ENGINEERING AND ENGINEERING MANAGEMENT

Course: Integrated management system (IMS)

Lecturer(s): Arsovski M. Slavko, Stefanovic Miladin

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives:

The subject objective is to equip students for independent scientific research in the field of different systems of management. Through theoretical lessons and case study, students will learn about the different systems of management with the development of integration models and integration of simulation results. Through a highly interdisciplinary and multidisciplinary research, students will be enabled to analyze, design, establishment and improvement of IMS.

Course outcomes

(1) Partial understanding of management, (2) Self-study of existing management systems and identify areas for improvement, (3) Self-modeling IMS and rating the effectiveness of a model of IMS, (4) Self-evaluation of the effects of model application and IMS.

Course content (Syllabus)

Theoretical teaching

Systematic approach. The theory of the system. Modeling of complex dynamic systems. Quality Management System (QMS). Environmental management system (EMS). Safety management system and health (OHSAS). Food safety management system (FMS). Risk Management System (RM). Information security management system (ISMS). Economics of quality management system (EQMS). Processes management. Technologies management. Supply chain management. Modeling the integration of different systems. Rating the quality of the model. Simulation and testing the impact of IMS. Management of IMS.

Practical teaching

Introduction with selected management systems. Independent analysis and synthesis of management system. Preparation of paper work.

Recommended reading

[1] Arsovski S., Process management, Center for quality, Faculty of mechanical engineering in Kragujevac, 2006, Kpagujevac

[2] Arsovski S., Quality management economy, CIM center, Faculty of mechanical engineering in Kragujevac, 2000, Kragujevac

[3] Arsovski S., Arsovski Z., Kokic M., Production and IC technologies management, Center for quality, Faculty of mechanical engineering in Kragujevac, 2007, Kragujevac

[4] Sterman J., Business Dynamics: Systems Thinking and Modeling for a Complex World, Me Graw Hill, Boston, 2000.

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods:

Teaching is conducted through lectures, visit companies and independent research.

Knowledge evaluation (maximum score 100 of points)

Paper work - 70,

Final exam -30.

Course: Analysis and design of Information Systems

Lecturer(s): Stefanović Ž. Miladin

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives:
The goal of the course is to provide advanced knowledge in the field of information systems, design of information systems, as well as computer networks and intelligent systems including Management information systems, decision support systems and data mining.

Course outcomes
Course provides detailed insight in advanced issues of information systems, modem approaches in analysis, design and implementation of information systems oriented toward industrial and business implementation. This results with student's knowledge and skills in analysis and implementation of advanced methodologies of design and implementation of information systems in various fields.

Course content (Syllabus)

1. Principles of modelling and structures
2. Data and process models – patterns
3. Internet interfaces for information systems component based software and web services
4. Ontology and semantic web
5. Advanced object-oriented information systems
6. IS and object-oriented and XML data bases
7. MS and data mining
8. OLAP and business intelligence
9. Industrial information systems
10. Information systems security

Recommended reading

1. McLeod, R.: Management Information Systems, Prentice Hall International London 1998, 655 p., ISBN 0-13-896101-8
2. Zora Arsovksi, Informacioni sistemi, CIM edicija, Mašinski fakultet, Kragujevac, 2005
3. Cichocki, A., Abdelsalam, H., Rusinkiewitz, M., Woelk, D.: Workflow and Process Automation - Concepts and Technology, Kluver Academic Publishers Dordrecht 1998, 114 p., ISBN 0-7923-8099-1

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods:
Theoretical lectures, practical work, lab work and independent work in preparing project.

Knowledge evaluation (maximum score 100 of points)
The exam is taken by submitting and presenting the project. Up to 70 points are related to the project and its presentation that integrates oral exam carries up to 30 points.

Course: Measurement and performance management of enterprise

Lecturer(s): Snežana Nestić

Status of the course: elective course, I semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

Defining the basis of a system for measuring, managing and coping with the methods of measurement and performance management of enterprises.

Course outcomes

Students will be able to apply the methods of measurement and performance management of enterprises in solving engineering and scientific research problems. They will know how to apply the principles of measurement and performance management of enterprises.

Course content
(Syllabus)

Theoretical teaching

Fundamentals of measurement and performance management. Organizing for measuring and managing performance. Use of information for measuring and information management. Creating a system for measuring performance. Measurement of product performance. Performance measurement process. Assessment of business based on the performance of companies. Assessing of the increased investment in quality. The challenges of performance management in the global economy. Establishing a consistent structure for the management of world-class performance. Alignment of short-term and long-term focus on business. Operationalization of value-based strategies. Creating transparency information. Empowering Business Conduct driven performance called. Integration of sub-systems and reducing their complexity. Achievement of business goals and strategies. Managing the value created in the companies.

Recommended reading

1. Simons, R., Performance Measurement & Control systems for Implementing Strategy, Prentice Hall, 2000
2. Waal A., Power of Performance Management, John Wiley & Sons, 2001
3. Iyer S., Managing for Value, New Age International Limited publishing, 2009.

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Theoretical study is performed through the usage of multimedia and interactive software tools. Practical study is held on a computer

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Up to 50 points are related to the project and its presentation that integrates oral exam carries up to 50 points.

Course: Advanced methods and control tools of industrial processes

Lecturer(s): Mačužić Ivan

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The objective of the course is to introduce the principles modern, methods and tools for industrial process control and business processes in general to the students. Starting with the business strategy, all elements of the industry and the business cycle are analysed in order to define the optimal approach, with intenion to ensure maximum utilization of available production and business resources.

Course outcomes

Through the methods of planning, management and integration of basic elements industrial and business processes (logistics, quality, maintenance, safety, and organizational issues) supported through the methods of cost management and human resources, doctoral student acquires the necessary theoretical knowledge to enable him to understand the complex and integrated approach of industrial and business processes management related to "world class" company. Production of world-class, as a concept and business philosophy, is a globally accepted model and goal for all business systems, as proivodne and service.

Course content
(Syllabus)

Modern production and business strategy; Lean concept and philosophy; world-class production; Toyota's Production System TPS, fundamentals of production of world-class basic systems (maintenance, security, logistics, quality, organization of jobs); 4P, methods, tools, standardization, leadership; Mapping of the flow value.

The concept of improvement in seven steps; focused improvement; KPI; maintenance management; autonomous and professional maintenance of production world-class systems; total productive maintenance and reliability based maintenance;

Total quality management and approach of continuous improvement- Kaizen; Logistics systems and supply chain management; JIT, JIS, Kanban, 5T, FIFO management and human resource development; Total inclusion of all employees. Management of health and safety at work and environmental protection; Standardization, 6S. Visual management in production and business systems

Recommended reading

1. J. Liker, The Toyota Way: 14 Management Principles, McGraw-Hill, 2004
2. M. Rother, Toyota Kata: Managing People for Improvement, Rother & Company, 2010
3. J. P. Womack, D. T. Jones, Lean Thinking, Free Press, 2003.

Number of active lectures: 10	Theoretical lectures: 5	Indipendent research work: 5

Teaching methods

Theoretical lectures are performed "ex cathedra" using multimedia.

Research work is carried out through an independent or team-work and this is based on "learning by solving the current problem."

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Up to 60 points takes the project and its presentation is the oral part of the exam carries 40 points.

Course: Advanced maintenance engineering

Lecturer(s): Ivan Mačužić

Status of the course: elective course, I semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The main objective is gaining knowledge in the field of advanced methods for equipment maintenance in modern production systems and processes, according to the current international criteria.

Other objectives are related to introduction of methods for identifying current and forecasting future conditions of resources is available or technical systems; mastering the skills necessary for systematic approach to increasing the effectiveness and reliability of the technical exploitation system.

Course outcomes

After this course, doctoral student:

has knowledge of systematic scientific approach in understanding the place and role of maintenance in modern industrial practice, can independently manage effectiveness of technical systems through maintaining, can independently select the diagnostic parameters and identify current and projected future state or available technical systems resources, and can independently improve maintainability and increases exploitation reliability of technical systems through a systematic approach.

Course content (Syllabus)

Theoretical study

Modern approach to the maintenance of technical systems; The structure and parameters of the state of technical systems; Maintenance and effectiveness of technical systems; Advanced methods of maintenance (RCM, proactive maintenance within the TPM, WCM and Lean Manufacturing concept of production); Methods of analysis of causes of failure; Technical diagnostics; Vibro diagnostics; Thermography; Analysis of the products of wear and tear; noise; Methods of non-destructive testing (NDT); The suitability of the technical systems maintenance; Exploitation reliability; Maintenance costs; Future of system maintenance

Practical study

Practical classes are conducted through independent work on the systematic problem-solving in the industry and with the use of modern diagnostic equipment (Data Collector B & K 2526 Software Sentinel, 5 channel PULSE Data Acquisition Unit B & K with software 7770-PULSE FFT Analysis and 7773 - PULSE Envelope Analysis, Sound Level Meter B & K 2250, Thermal imager Thermoco P640 with associated software, Flexible articulated videoscope VEZ 4-8., System diagnosis of status of various types of industrial mineral oils., etc.).

Recommended reading

- Wang H., Pham., Reliability and Optimal Maintenance, Springer, 2006.
- Nakajima, S., TPM Development Program , Productivity Press, 1989.
- Blanchard, B., Verma, D., Pererson, E., Maintainability, John Wiley and Sons, INC,1995
- Cornelius S, Paresh G., Practical Machinery Vibration Analysis and Predictive Maintenance, ISBN:0750662751, Newnes Publication, 2004
- Roderick T., Thermography Monitoring Handbook, ISBN: 1901892018, Coxmoor Publishing Company, 1999
- Brian R, Trevor H., The Wear Debris Analysis Handbook, ISBN: 1901892026, Coxmoor Publishing Company, 1999
- 7. Јеремић Б., Тодоровић П., Комплексна дијагностика ротора, Монографија, ISBN: 978-86-8663-21-4, Машински факултет у Крагујевцу, 2007.

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5
Teaching methods Theoretical lectures are performed "ex cathedra" using multimedia. Practical classes are conducted through an independent or team-work and is based on "learning by solving the current problem."		
Knowledge evaluation (maximum score 100 of points) The exam is taken by submitting and presenting the project. Up to 60 points takes the project and its presentation is the oral part of the exam carries 40 points.		

Course: Business intelligence

Lecturer(s): Danijela Tadić, Aleksandar Aleksić

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives:

The goal of course is to equip students for independent scientific research in the field of various business intelligence systems. Through theoretical lessons and case study, students will learn about the different systems of business intelligence with the development of models and simulations of the effects of the development of business intelligence. Through this interdisciplinary and multidisciplinary research will enable students to analyze, design, establish and improve business intelligence.

Course outcomes

(1) Understanding the importance of business intelligence, (2) Independent investigation of certain aspects of business intelligence, (3) individual work in modeling and designing systems to support business intelligence.

Course content (Syllabus)

Theoretical teaching

(1) The systematic approach, (2) Knowledge management, (3) The complexity of the system, (4) The characteristics of complex business problems, (5) Adaptive Business Intelligence, (6) The methods and prediction models, (7) Modern techniques for optimization, (8) Fuzzy logic, (9) Artificial neural network (10) Other methods and techniques, (11) Hybrid systems and adaptability

Practical teaching

(12) Business Intelligence in manufacturing systems, (13) Business intelligence in business systems, (14) Development of business intelligence for the recycling of vehicles examples, (15) Preparation of seminar work.

Recommended reading

[1] T' Kindt V., Billaut J. C., Multicriteria Scheduling: Theory, Models and Algorithms, Springer, Berlin, 2006.

[2] Mertius K., Heisiger P., Vorbeck J., Knowledge Management, Springer, Berlin, 2002.

[3] Michalewicz Z., et al., Adaptive Business Inteligence, Springer, Berlin, 2007.

[4] Pietersen W., Reinventing Strategy: Using Strategic Learning to Create & Sustain Breakthrough Performance, Jonh Wiley & Sons, New York, 2002.

[5] Kaplan R., Norton D., Alignment: Using BSC to Create Corporate Synergies, Haward Business School Pres, Boston, 2006.

[6] Sterman J., Business Dynamics: Systems Thinking and Modeling for a Complex World, Mc Graw Hill, Boston, 2000.

[7] Turban E., Arousen J., Decision Support Systems and Inteligent Systems, Prentice Hall, 2001.

[8] George M., Wilson S., Conquering complexity in your business, Mc Grow Hill, New York, 2004.

[9] Maxton G., Wormald J., Time for a Model Change, Cambridge University Press, Cambridge, 2004.

Number of active lectures: 20	Theoretical lectures: 10	Practical lectures: 10

Teaching methods:

Teaching is conducted through lectures and independent research.

Knowledge evaluation (maximum score 100 of points)

Paper work - 70,

Final exam -30.

Course: Management system of occupational of health and safety

Lecturer(s): Marko Đapan

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The aim of the course is to introduce the modern principles, methods and technologies that enable improved access and governance system of health and safety at work in the industry and business environment to candidates. Starting from the expressed multidisciplinary characteristic of the area of safety and health at work, various aspects and factors of the OHS, the technological, organizational through to human are covered.

Course outcomes

Through the demonstration and analysis of the viability and feasibility of the application of modern approaches, methods and technologies for the improvement of occupational safety and health, a PhD student acquires the necessary theoretical knowledge to enable him to perform complex analysis and security risk assessment, using advanced mathematical and computer tools and advanced metering systems.

Course content
(Syllabus)

1. Basic principles, legal frameworks and standardization system of ocupational health and safety
2. Techniques and methods for identifying hazards in the workplace
3. Analysis of security through case studies and accidents
4. Advanced methods for risk assessment and its mathematical modeling
5. Methods for testing and control of physical hazards
6. Advanced analysis of ergonomic aspects in the workplace
7. Health in the workplace, stress, biomedical aspects of security
8. The human factor in security system
9. Basic principles of organization and ocupational health and safety management system
10. System integration of ocupational health and safety in the business environment, information system of ocupational health and safety
11. Lean philosophy in the system of ocupational health and safety
12. Education in the cupational health and safety system

Recommended reading

1. N. J. Bahr, System Safety Engineering and Risk Assessment, Taylor & Francis, 1997
2. N. G. Levenson, Engineering a Safer World: Systems Thinking Applied to Safety, The MIT Press, 2011
3. Trevor Kletz, Learning from Accidents, Gulf Professional Publishing, 2001

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Theoretical lectures are performed "ex cathedra" using multimedia. Practical classes are conducted through an independent or team-work and is based on "learning by solving the current problem."

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Up to 60 points takes the project and its presentation is the oral part of the exam carries 40 points.

Course: Digital Manufacturing

Lecturer(s): Erić D. Milan

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

Acquisition of knowledge, theoretical and practical in the field of digital manufacturing and digital models and methods that describe all aspects life-cycle products.

Course outcomes

By acquiring the necessary knowledge and skills candidates will be able to know and understand integrated, developed and implemented various innovative processes in designing disciplines such as: product design, process planning, layout planning, modelling processes, process simulation, and production management.

Course content
(Syllabus)

Theoretical study

Engineering activities. Industrial motivation for digital manufacturing. Concurrent Engineering. Simulation: methodology, technology and processes. Application of simulation in manufacturing: simulation of flow manufacturing, assembly simulation, production process simulation, ergonomics simulation, robotic simulation, time management. Advanced manufacturing engineering based on modern IC technologies.

Research study:

Study research is realized through the independent research related to digital manufacturing, using modem IC technology.

Recommended reading

1. Lihui Wang, Andrew Y.C. Nee, Collaborative Design and Planning for Digital Manufacturing, Springer, 2008
2. Pedro F. Cunha, Paul G. Maropoulo, Digital Enterprise Technology- *Perspectives and Future Challenges*, Springer, 2007
3. atko V. Mitrović, Projektovanje tehnoloških procesa, Naučna knjiga, Beograd, 1991

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Theoretical teaching is performed "ex cathedra" with the use of multimedia content and interactive software tools. Study research is implemented through an independent and team research in the project.

Knowledge evaluation (maximum score 100 of points)

The exam is passed by presenting project results. Project quality brings up to 60 points, and its presentation up to 40 points.

Course: Computational Intelligence in Engineering

Lecturer(s): Ranković M. Vesna

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The main objective of the course is to introduce the theories and techniques of computational intelligence to PhD students. In that manner, neural networks, genetic algorithms, fuzzy systems, hybrid systems are studied.

Other objectives are related to gaining knowledge and experience about the possibilities of application of computational intelligence techniques in modeling different system, predicting and optimizing.

Course outcomes

After the completion of the work on this subject, students will master the areas of computer intelligence (artificial neural networks, genetic algorithms, fuzzy systems, hybrid systems) and they will be able to apply and successfully to solve different problems (classification, modeling, prediction, and optimization) in different areas of technology.

Course content (Syllabus)

Theoretical study

Introduction. Definition and basic properties. Typical problems and areas of application. Typical tools. Neural networks. The basic ideas. Architecture. Classification of neural networks. Training of the neural network. Reliability and stability. Model validation. Software tools for neural networks. Fuzzy logic and fuzzy systems. Fuzzy sets and rules. Approximate reasoning. Theoretical and linguistic aspects of the fuzzy logic. Structure of fuzzy system. Software tools for fuzzy systems. Genetic algorithms (GA). Presentation of the solution. Generating the initial population. The objective function. Selection. Recombination. The mutation. Optimization using genetic algorithm. Genetic Algorithm as a global optimization technique. Machine learning using GA. Software tools for GA. Hybrid systems. Combining neural networks, fuzzy systems and evolutionary algorithms.

Practical study

A project with practical and concrete problem is oriented to work with software that allows the implementation of computational intelligence techniques. Other activities are oriented to study of research papers in the field of computational intelligence.

Recommended reading

1. Engelbrecht, A.P., Computational Intelligence: An Introduction, John Wiley, New York, 2003.
2. Rutkowski, L., Computational Intelligence: Methods and Techniques, Springer, 2008.
3. Jang, J.S.R., Sun, C.T., Mizutani, E., Neuro-fuzzy and soft computing: A computational approach to learning and machine intelligence. Prentice-Hall, Upper Saddle River, NJ, 1997.

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Lectures, interactive sessions and individual work.

Knowledge evaluation (maximum score 100 of points)

The exam is passed by presenting project results. Project quality brings up to 60 points, and its presentation up to 40 points.

Course: Computer integrated enterprises and manufacturing

Lecturer(s): Snežana Nestić

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The objective of the course is to present detailed information about technologies in industrial enterprises with special emphasize on computer systems in different production / business processes (development of new products, communication, customer satisfaction...)- Course covers design of products and process, management with product data, architecture of industrial information systems, integration concepts and technologies and further development..

Course outcomes

Course presents wide specter of different application of complex and advanced computer and information systems and technologies on the most important production and business processes in enterprise. The main outcome of the course is knowledge in design of complex information and computer systems in different engineering, production and business fields.

Course content (Syllabus)

Theoretical study:

1. Principles of advanced design CIE/CIM systems
2. Complex information systems in CIE/CIM
3. Computer integrated engineering, advanced
4. Computer controlled production systems
5. Quality and control in CIE
6. Integration of systems (ERP, SCM, CRM, EA1)
7. Enterprise Information systems - EIS
8. Knowledge management in CIE/CIM
9. Management with CIE/CIM technologies

Research study:

Research in the specific filed using advanced methodology.

Recommended reading

1. K. Asai, (Editor), et al Edition "Manufacturing, Automation Systems and CIM Factories", Springer; ISBN: 0412482304
2. James A. Rehg „Introduction to Robotics in CIM Systems" (5th Edition)" , Prentice Hall; 5 edition (March 8, 2002), ISBN 0130602434
3. Миладин Стефановић. ЦИМ системи, Машински факултет у Крагујевцу, 2006

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Lecturers, seminars, research study, laboratory work.

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Seminar paper - research study 70, final exam 30.

Course: The methods of artificial intelligence in management

Lecturer(s): Tadić P. Danijela

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The main objective is to introduce the skills of mathematical theories that belong to the group of soft computing, primarily in solving decision problems that belong to different domains.

Course outcomes

After passing the exam, the student should be able to: (1) model the various types of uncertainty by using different methods of soft computing (fuzzy set theory, genetic algorithms and other evolutionary methods, heuristic methods, multiple-criteria optimization), (2) solve management problems by application of optimization methods.

Course content
(Syllabus)

Theoretical study

Theoretical study: (1) the theory of fuzzy sets (basic notions, operations on fuzzy sets, methods for comparing fuzzy numbers), and its application in the modeling of uncertainty, (2) fuzzy logic; Development and application of methods of decision making that are based on fuzzy logic, (3) genetic algorithms and their applications, (4) the modification and application of multi-criterion decision-making methods (5) the application of heuristics and heuristic methods (concept, the concept of environment, local search methods, method of changing the environment) to solve the problem.

Practical study

Practical teaching: Problem soving practice and independent work.

Recommended reading

1. D. Tadić, i dr., Teorija fazi skupova-primene u rešavanju menadžment problema, Mašinski fakultet u Kragujevcu, Kragujevac, 2006. ISBN:86-80581-98-4
2. H.J. Zimmermann, *Fuzzy sets theory and its applications*, Kluwer Academic Publishers, Boston/Dordrecht/London, 2001.ISBN:0-7923-7435-5
3. G.J.Klir, T.A. Folger, Fuzzy sets, Uncertainty, and Information, Prentice Hall, Englewood Cliffs, New Jeresy, 1988.ISBN:0-13-345984-5
4. M.M.Gupta, T.Y.amakawa (eds). Fuzzy logic in Knowledge-based systems, decision and Control, *ELVISER SCIENCE PUBLISHERS B.V., netherlands*, 1988,ISBN: 0-444-70450-7

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Working in small groups, individual teaching.

Knowledge evaluation (maximum score 100 of points)

Activity during lectures: 10 points, colloquia: 20 points, seminars: 40 points, written exam: 25 points, an oral exam: 5 points.

Course: Business models of enterprises

Lecturer(s): Aleksandar Aleksić

Status of the course: elective course, I semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The main objective is presentation of the business models of enterprises to PhD students.

Course outcomes

After passing the course, PhD students will be able to apply models of business. They will know to apply the principles of business models.

Course content (Syllabus)

Theoretical study

Model of objectives. Model of human resources and knowledge. Model of stakeholders. Model of business rules. Information model. Model of business processes. Model of business performance. Model of technological resources. Model of requirements. Model of quality. Model of sustainability. Model of development. Model of companies. Model of changes. Model of interface with the environment. Simulation model. Model of decision making. Tools for modeling business. Methods for modeling enterprise business

Recommended reading

1. Wilson P., Pearson R., Performance – Based Assessment, ASQC Quality Press, 1995
2. Oehler K., Performance management mit Business Intelligence Werkzeugen, Hanser Verlog, 2006.

Number of active lectures: 10	Theoretical lectures: 5	Indipendent research work: 5

Teaching methods

Theoretical lectures are performed "ex cathedra" using multimedia. Practical classes are conducted through an independent or team-work and is based on "learning by solving the current

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Up to 50 points takes the project and its presentation is the oral part of the exam carries 50 points.

Course: Modeling and optimization in the field of energy and environment

Lecturer(s): Jovičić M. Nebojša

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The main objective is introduction to basic optimization methodologies of real processes in the energy and environmental engineering; Other objectives are related to introduction of numerical optimization algorithms, and computer simulations of typical processes that belong to the group of heavy optimization problems.

Course outcomes

After completion of this course the PhD student will be able to 1) understand the importance of the application of optimization algorithms for solving the problems of energy, process technology and environmental protection, 2) competently analyze and apply appropriate optimization algorithm to a real problem, 3) independently carry out the simulation and optimization of typical process using specialized software, 4) present the results of computer simulation with the presentation of actual improvements and energy savings.

Course content (Syllabus)

Theoretical study

- Review, division and optimization capabilities of typical engineering problems; Introducing the class of difficult combinatorial optimization problems; Typical difficult to solve optimization problems -TR problem: Traveling Salesman Problem (TSP problems), Vehicle Routing Problem (VRP problems); Classification of VRP problem; Examples in practice difficult problems konbinatorne optimization.
- Review of algorithms for solving optimization problems TR: Combinatorial algorithms Heuristic and metaheuristics algorithms.
- Review metaheurističkih algorithms based on the behavior of animals: an ant colony, swarm of bees.
- Optimization of transport processes using ant colonies (IF optimization).

Practical classes:

Exercises in a computer classroom:

Application of VRP problems in the optimization of collection and disposal of solid waste. Using GPS and GIS system for location identification problem of waste collection. Computer simulation optimization problems of waste collection. Analysis of specific solutions obtained during the optimization of different parameters in particular optimization problems.

Recommended reading

1. Doriego M., Stutzle T. Ant colony optimization, Cambridge Massachusetts, England, 2004
2. Carić T., Improvement of transport organization applying heuristic methods, Ph.D. Thesis, University of Zagreb, Faculty of Transport and Traffic Sciences, 2004
3. Chong and Zak, An Introduction to Optimization, Wiley Interscience Series in Discrete Mathematics and Optimization, Second edition, ISBN-0-471-39126-3

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Teaching: lectures and exercises are conducted in a computer classroom.

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project task.

Course: Energy management

Lecturer(s): Gordić R. Dusan

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives:
The objective of the course is to accomplish scientific and creative capabilities and academic skills related to contemporary methods of energy management.

Course outcomes:
After completing the course, a student will be able to:

Independently solve practical and theoretical problems related to the content of the course.
Independently and team work in all phases of energy management studies and projects.

Course content (Syllabus)

Theoretical study

The importance of energy management and its relation with environmental protection, energy balancing: methodology, trends analysis, measuring equipment, energy indicators, economics of production and use of energy, modern technologies and energy efficiency measures (steam systems: testing the efficiency of boilers, control of excess air, steam distribution and the use of steam traps, condensate return, use of vapour steam, thermal insulation; electrical systems: demand control, power factor correction, electric drive-control efficiency, energy-efficient motors, speed control motors; lighting: level of lighting, types of lamps, ballasts, active use of lighting, time switches, energy efficient windows; energy savings in pump, fan and compressed air systems, energy savings in cooling and HVAC systems; use of waste heat: recovery, heat pipes, heat pumps, cogeneration (concepts, options, criteria selection, management strategies), energy management in a company, function and position of an energy manager, development of energy management program, monitoring and control of implementation, Domestic legal regulations (laws, bylaws, regulations and standards); EU Directives in the field energy management and environmental protection

Research study:

Project assignment in the field of energy management. Project task can be in the form of study, mathematical and/or computer model, the energy balance at a particular manufacturing plant. Report is presented to other course participants at the end of the semester.

Recommended reading:

1. Capeheart, L. B., Turner, W. C., Kennedy, W. J., Guide to Energy Management, The Fairmont Press and Marcell Dekker Inc., Fourth Edition, USA, 2003
2. Turner, W. C., Energy Management Handbook - Third Edition, The Fairmont Press, 1997.
3. Thumann, A., Plant Engineers and Managers Guide to Energy Conservation, The Fairmont Press and Marcell Dekker Inc., USA, 2002

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Theoretical lecturing is done in classrooms by using multimedia. Theoretical solutions with examples are given for each educational unit.

Practical teaching is performed in computer classroom and industry where students independently work on the selected practical problems -project assignments.

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submission and presentation of the project. The project - 50 points, project presentation (integrates the oral part of the examination) - 50 points.

Course: Theory and techniques of experiment

Lecturer(s): Tadić U. Branko

Status of the course: elective course, III semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives

The objective of the course is to introduce the theoretical basis and techniques for conducting of complex experiments to the students.

Course outcomes

Through the theory and techniques of planning and conducting of experiments in the field of mechanical engineering, doctoral student acquires the necessary theoretical knowledge to conduct complex experiments independently.

Course content (Syllabus)

Theoretical teaching

Theory and planning of engineering experiment. Structures and types of experiments. Model tests and theory of similarity. The role of experiment in science and the role of experiment in product development, product design and redesign. Measuring instruments and systems of measuring chains – characteristics, calibration and selection criteria. Errors in planning of experiment, systematic errors, random errors, reliability assessment. Data collection and statistical processing of data or measurement results, as well as the presentation of measurement results. Project objective realization success analysis. Analysis of the sample experiments realized in order to achieve product development, product design and redesign.

Practical teaching

Practical teaching is realized through individual theoretical and experimental research. Subjects of experimental research belong to the field of fenomena related to production engineering and industrial engineering.

Recommended reading

1. Holman J. P.: Experimental methods for engineers, McGraw-Hill, New York, 1989.
2. Grujović A. G. : Tehnička merenja I - Osnovi teorije merenja, Mašinski fakultet u Kragujevcu, Kragujevac, 1999.
3. Josifović D.: Ispitivanje mašinskih konstrukcija I, Mašinski fakultet u Kragujevcu, Kragujevac, 2000.
4. Morris A.: Measurement and instrumentation principles, Ed. B./H., Oxford, 2001.
5. Osita N., Yildrim H.: The mechanical systems design handbook, (Modeling, measurement and control), Ed. CRC PRESS, London, 2002.

Number of active lectures: 4	**Theoretical lectures:** 2	**Indipendent research work:** 2

Teaching methods

Theoretical lectures are performed "ex cathedra" using multimedia and interactive software tools. Research work is carried out through an independent or team-work, based on "learning by solving the current problem."

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. The project takes up to 60 points and its presentation is the oral part of the exam carries 40 points.

Course: Product design optimization

Lecturer(s): PhD Lozica Ivanović

Status of the course: elective course, II semester

No. of ECTS: 15

Prerequisite courses: N/A

Course objectives:

The main objective of the course is to integrate traditional design methodologies with the concepts and techniques of modern optimization theory and practice. Introduction to the student with methods and tools for optimization in the multidisciplinary product design context. The specific objective of the course is to teach the student to create an appropriate simulation model of product design problems, to formulate the problem of optimization, and to use numerical optimization techniques and computer support tools to effectively solve the problem.

Course outcomes:

After completion of the course the student should be able to:

1. Identifies opportunities to improve the new design or existing product design
2. Formulate appropriate product design optimization problems
3. Analyze optimization formulations
4. Become familiar with advanced methods and tools to solve problem optimization
5. Run designs of experiments
6. Creating surrogate models (metamodels)
7. Understand the basic principles of common optimization algorithms
8. Choose appropriate optimization algorithms for a problem
9. Solve problems using algorithms in MATLAB, Excel, Minitab and others programs.
10. Interpret optimization results for product design decision making
11. Formulate and solve multi-objective optimization problems
12. Formulate and solve multi-disciplinary optimization problems

Course content
(Syllabus)

Theoretical study

Design methodology as a framework that integrates theoretical concepts from different scientific disciplines. Defining design in a broad context, as an activity to solve engineering problems. Optimization as a support to solving the design process problems in the early stage of product development. Optimization and evolutionary design. Optimum Design Concepts. Overview of principles, methods and tools in design optimization. Traditional and advanced optimization methods. Design of experiments and metamodels. Optimization of dimensions, shape and topology. Multi-objective and multidisciplinary optimization. Robust design. Taguchi method. Six Theta® design.

Practical study

1. A project with a practical and concrete problem of product design optimization, where students will work on problem formulation, modeling, problem solving and analysis of the results obtained.
2. Study of scientific works in the field of the project.

Recommended reading

1. Ulrich, K., Eppinger, S., Product Design and Development, McGraw-Hill/Irwin, 2003.
2. Arora, J.S., Introduction to Optimum Design, Elsevier Academic Press, 4th edition, 2017.
3. Cross, N., Design Thinking: Understanding How Designers Think and Work, New York, USA, 2011.
4. Martins, J., Ning, A., Hicken, J., Multidisciplinary Design Optimization, 2017.
5. http://www.cee.ucla.edu/doctoral-programs-structure/

Number of active lectures: 10	Theoretical lectures: 5	Practical lectures: 5

Teaching methods

Lectures, interactive teaching and independent work.

Knowledge evaluation (maximum score 100 of points)

The exam is taken by submitting and presenting the project. Up to 60 points takes the project and its presentation is the oral part of the exam carries 40 points.

Course: Laboratory, research, publishing - Independent Research Work - overview of the results in the scientific field

Lecturer(s): Mentor of doctoral dissertation

Status of the course: mandatory course, IV semester

No. of ECTS: 20

Prerequisite courses: N/A

Course objectives

The doctoral dissertation must have a defined subject of scientific debate. Therefore, in preparation it is necessary to do a thorough review of the scientific field of doctoral dissertations.

Course outcomes

It is recommended that the quality of reviews should be verified in the field by publishing of the review paper. Based on a review of the field, the objective of dissertation should be defined, as well as the different possibilities of dissertation's original contribution. These possibilities for contribution should be analyticaly analysed, simulated and experimentally verified (the nature of the expected contribution should define the need for inclusion of defined measures). The candidate should adopt the approach for comparison of previous solutions and concepts, and those that will be the outcome of a doctoral dissertation. Definition / determination of the subject of scientific debate in the future dissertation is an important outcome that is expected.

Course content (Syllabus)

It is formed individually in accordance with the needs of developing specific doctoral dissertation and it is dictated by the current events in the chosen field of science. Student should study relevant literature.

Recommended reading

1. Relevant scientific literature: journals, monographs, doctoral dissertations, etc.

Number of active lectures:	Theoretical lectures:	Practical lectures: 20

Teaching methods

Mentor of docrtoral dissertation should prepare a work plan and submit it to the PhD student. The PhD student is required to study the literature that is proposed by the mentor. Through study research, the study of literature, determination in the field, the interaction student - mentor the subject of scientific debate doctoral dissertation should be defined. Within the research study, the student consults with the mentor, and if necessary, with other teachers who are dealing with the problems of the current field. PhD student if necessary performs specific measurements, tests, count, surveys and other research, statistical analysis, if there is research interest in this phase of the development research.

Knowledge evaluation (maximum score 100 of points)

Seminar paper is rated with 80 points, and the final presentation is rated with 20 points.

The tests of knowledge may be different: a written exam, oral exam, project presentations, seminars, etc.

Course: Laboratory, research, publishing - Independent Research Work – systematization of theoretical range

Lecturer(s): Mentor of doctoral dissertation

Status of the course: mandatory course, V semester

No. of ECTS: 20

Prerequisite courses:

Course objectives

The main objective is employement of basic, theoretical methodological, scientific and technical and professional application of knowledge and methods to solve practical problems within the subject of scientific debate doctoral dissertation. In this part of the dissertation, PhD student is studying the problem, its structure and complexity on the basis of the analysis, conclusions about possible ways of solving it. By studying literature, methods that are designed to creatively solve new tasks and engineering practice in solving them are introduced to PhD students. The aim of the students' activities in this part of the research is to gain the necessary experience through solving of complex problems and tasks, and identify opportunities for the application of previously acquired knowledge into practice.

Course outcomes

The main outcome is enabling students to independently apply previously acquired knowledge in different areas that have been previously studied, in order to assess the structure of the original problem and its system analysis in order to draw conclusions about the possible directions of its resolution. Through the independent use of literature, students expand their knowledge in selected areas and explore different methods and papers related to similar issues. In this way, the students develop ability to conduct analysis and identify problems within a given theme. Practical application of acquired knowledge with all types of areas enable the students to develop the ability to look at the place and role of engineers in the selected area, the need for cooperation with other professions and teamwork.

Course content (Syllabus)

It is formed individually in accordance with the needs of developing specific doctoral dissertation, its complexity and structure. Student is studying literature, doctoral theses of students who are working on similar issues, the analysis is performed in order to find a solution for a specific task, which is defined task doctoral dissertation.

Recommended reading

1. Relevant scientific literature: journals, monographs, doctoral dissertations, etc.

Number of active lectures:	Theoretical lectures:	Practical lectures: 20

Teaching methods

Mentor of doctoral dissertation compiles the work of the task and submit it to the PhD student. The PhD student is required to prepare doctoral dissertation within a given topic, which is defined by task of doctoral dissertation, using literature proposed by the mentor. During the preparation of the doctoral dissertation mentor can provide additional guidance to student, refer to specific references and further directed him in order to develop high-quality doctoral dissertation. Within the research study student conduct consultation with the mentor, and if necessary, with other teachers that deal with topics in the field of the paper. Within a given topic, the student, if necessary, perform specific measurements, tests, counts, surveys and other research, statistical analysis, if it contributes to a doctoral dissertation.

Knowledge evaluation (maximum score 100 of points)

Seminar paper is rated with 80 points, and the final presentation is rated with 20 points.

The tests of knowledge may be different: a written exam, oral exam, project presentations, seminars, etc.

Course: Laboratory, research, publishing - Independent Research Work

Lecturer(s): Mentor of doctoral dissertation

Status of the course: mandatory course, VI semester

No. of ECTS: 20

Prerequisite courses:

Course objectives

Research study from the previous semester should be continued. Employement of basic, theoretical methodological, scientific and technical and professional application of knowledge and methods to solve practical problems within the scientific debate. In this part of the dissertation student is studying the problem, its structure and complexity on the basis of the analysis, conclusions about possible ways of solving it. By studying literature, methods that are designed to creatively solve new tasks and engineering practice in solving them are introduced to students. The aim of the activities of the students in this part of the research is to gain the necessary experience through solving complex problems and tasks, and identify opportunities for the development of original scientific contributions.

Course outcomes

The main outcome is enabling students to independently apply previously acquired knowledge in different areas that have been previously studied, in order to assess the structure of the original problem and its system analysis in order to draw conclusions about the possible directions of its resolution. Through the independent use of literature, students expand their knowledge of the chosen field of study and the different methods and papers relating to similar issues. In this way, the students develop the ability to conduct analysis and identify problems within a given topic. Practical application of acquired knowledge in different areas the students develop the ability to look at the place and role of engineers in the selected area, the need for cooperation with other professions and teamwork. Original contributions that should be included in the doctoral thesis are desirable outcome in this phase of the research, because without such contributions and their publication in the respective journals, doctoral dissertation can not be completed.

Course content (Syllabus)

It is formed individually in accordance with the needs of developing specific doctoral dissertation, its complexity and structure. Student is studying literature, doctoral theses of students who are working on similar issues, the analysis is performed in order to find a solution for a specific task, which is defined task doctoral dissertation.

Recommended reading

1. Relevant scientific literature: journals, monographs, doctoral dissertations, etc.

Number of active lectures:	Theoretical lectures:	Practical lectures: 20

Teaching methods

Mentor of doctoral dissertation compiles the work of the task and submit it to the PhD student. The PhD student is required to prepare doctoral dissertation within a given topic, which is defined by task of doctoral dissertation, using literature proposed by the mentor. During the preparation of the doctoral dissertation mentor can provide additional guidance to student, refer to specific references and further directed him in order to develop high-quality doctoral dissertation. Within the research study student conduct consultation with the mentor, and if necessary, with other teachers that deal with topics in the field of the paper. Within a given topic, the student, if necessary, perform specific measurements, tests, counts, surveys and other research, statistical analysis, if it contributes to a doctoral dissertation.

Knowledge evaluation (maximum score 100 of points)

Seminar paper is rated with 50 points, and the final presentation is rated with 50 points.

The tests of knowledge may be different: a written exam, oral exam, project presentations, seminars, etc.