University of Kragujevac

Faculty of Engineering

The Book of Courses
Master Academic Studies
Bioengineering

Kragujevac, 2018

MASTER ACADEMIC STUDIES - BIOENGINEERING

First year							
I				**II**			
AG **Fundamentals of Anatomy and Physiology** 6 ECTS				AG **Bioengineering and Bioinformatics** 6 ECTS			
3	1,4	0,6	0	2	1,6	0,4	0
PA **Elective course 1** 6 ECTS				PA **Elective course 4** 6 ECTS			
3	1,4	0,6	0	2	1,6	0,4	0
PA **Elective course 2** 6 ECTS				TM **Study research work on the theoretical bases of Master's thesis** 8 ECTS			
3	1,4	0,6	0	0	0	0	16
PA **Elective course 3** 6 ECTS				PA **Master' thesis** 10 ECTS			
3	1,4	0,6	0				
PA **Technical practice 2** 6 ECTS							
0	0	0	0	0	0	0	0
L	AE	LE	SRW	L	AE	LE	SRW
Total (class/week)							
12	5,6	2,4	0	4	3,2	0,8	16
12	8			4	20		
20				24			
Total ECTS							
30				30			

Legend: L – lectures, AE – auditory exercises, LE – laboratory exercises, SRW – study research work

Course type:

- AG – academic general education
- TM - theoretical-methodological
- PA – professional-applicative

No.	Course code	Course	ECTS	First year	
				I	II
1.	MBE1100	Fundamentals of Anatomy and Physiology	6	3+1,4+0,6+0	
2.	MBE120x	Elective course 1	6	3+1,4+0,6+0	
3.	MBE120x	Elective course 2	6	3+1,4+0,6+0	
4.	MBE120x	Elective course 3	6	3+1,4+0,6+0	
5.	MBE1300	Technical practice 2	6	0+0+0+0+0	
6.	MBE210x	Bioengineering and Bioinformatics	6		2+1,6+0,4+0
7.	MBE2200	Elective course 4	6		2+1,6+0,4+0
8.	MBE2300	Study research work on the theoretical bases of Master's thesis	8		0+0+0+16
9.	MBE2400	Master's thesis	10		/
		Number of courses/semester		5	4
		Classes per week		20	24
		ECTS		30	30

Elective course 1, 2, 3 - 3 are selected out of 9 offered

1.	MBE1201	Computational Mechanics of Fracture and Damage
2.	MBE1202	Computational Fluid Dynamics
3.	MBE1203	Biomedical Image Processing
4.	MBE1204	Biomaterials
5.	MBE1205	Tissue Engineering
6.	MBE1206	Biomedical Instrumentation and Measurement
7.	MBE1207	Design of Biomedical Devices
8.	MBE1208	Ergonomics in Bioengineering
9.	MBE1209	Communication Protocols Programming

Elective course 4 - 1 is selected out of 4 offered

1.	MBE2101	Artificial Intelligence
2.	MBE2102	Advanced Analysis and Computer Simulation of Systems
3.	MBE2103	Musculoskeletal Systems
4.	MBE2104	Nanomaterials in Bioengineering

Study programme: Bioengineering		
Course name: Fundamentals of Anatomy and Physiology		
Lecturer: Irena Tanasković, Dejan Jeremić, Vladimir Živković		
Status of the course: Mandatory		
No. of ECTS: 6		
Precondition: None		

Course objectives

To introduce students to the morphofunctional characteristics of human cells, tissues and organs.

Course outcomes

Upon completion of the course entitled Fundamentals of Anatomy and Physiology, the students are expected to acquire knowledge about:

- General anatomical features of organ systems
- General characteristics of the structural organization of cells, tissues, organs and organ systems
- Fundamentals of physiology of organ systems
- The way tissues are organized into organs and organ systems
- Histological and physiological characteristics of tissues and organs
- Basic rules of the relationship between the structure of tissues and organs and their function and dysfunction

Upon completion of the course entitled Fundamentals of Anatomy and Physiology, a student is expected to acquire the following skills:

- to identify basic types of cells and tissues;
- to recognize histological structure of human organs.

Course content

Theoretical classes

Fundamentals of anatomy and physiology of organ systems. Basic characteristics of epithelial, connective, muscle and nervous tissue. Morphofunctional characteristics of the circulatory, immune, digestive, respiratory, urinary, endocrine, nervous and reproductive system, sensory organs and skin.

Practical classes

Identifying basic characteristics of the circulatory, immune, digestive, respiratory, urinary, endocrine, nervous and reproductive system, sensory organs and skin.

Literature

- Lecture presentations
- Anđelković Z, Somer Lj, Matavulj M, Lačković V, Lalošević D, Nikolić I, Milosavljević Z, Danilović V. Cells and Tissues (in Serbian), GIP Bonafides, Niš, 2002.
- Anđelković Z, Somer Lj, Perović M, Avramović V, Milenkova Lj, Kostovska N, Petrović A. Histological Structure of Organs (in Serbian), GIP Bonafides, Niš, 2001.
- Anđelković Z et al. Histology (in Serbian). First edition. Impressum, Niš, 2009.

Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**
Teaching methods		

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**30**	written exam and oral exam	**70**

Study programme: Bioengineering/Mechanical Engineering/Computer Techniques and Software Engineering

Course name: Bioengineering and Bioinformatics

Lecturer: Filipović Nenad, Jovičić Gordana, Isailović Velibor, Dunić Vladimir

Course status: Mandatory

No. of ECTS: 6

Precondition: None

Course objectives

The aim of the course is to introduce students to possible applications of bioengineering and bioinformatics in the field of modelling of cardiovascular systems, cardiac excitation-contraction coupling, biomechanics of bones, spine and cartilages, micro and macro scale connecting, combination of biochemical reactions and use of databases and artificial intelligence methods as search tools in bioinformatics.

Course outcomes

After they have mastered the programme and passed the exam within the course entitled Bioengineering and Bioinformatics, the candidates will be able to engage in scientific research in this very popular and interdisciplinary field. The candidates will acquire knowledge of basic concepts in cardiovascular biomechanics, mechanism of circulation, biomechanics of muscles, biomechanics of bones and spine, basics of bioinformatics, parallel systems and the use of bioinformatics databases and artificial intelligence methods in modelling and simulating coupling problems in cardiovascular system.

Course content

Theoretical classes

Basic concepts in cardiovascular biomechanics. Basic principles of circulation. Forces and resistance to blood flow. Newton's law of fluid motion. The concept of turbulence. Blood rheology. Mechanisms of circulation. Heart, electrical system. Heart mechanics. Function of heart valves. Active contraction. Solid-fluid interaction. Experimental determination of deformations. Constitutive relations. Blood flow in arteries. Biomechanics of spine and cartilage. Basics of bioinformatics. Parallel systems in bioinformatics. Methods of artificial intelligence in bioinformatics. Application of bioinformatics in medicine.

Practical classes

Development of a real computer model in the area of cardiovascular biomechanics.

Literature

1. Filipović N., Basic Bioengineering (in Serbian), Faculty of Engineering, Kragujevac, 2012. ISBN 978-86-86685-66-7.
2. Filipović, N. Modelling and Simulation of Cardiovascular System (in Serbian), WUS Austria, CIMSI, University of Kragujevac, 2005.
3. Fung, Y. C. Biodynamics: Circulation, Springer-Verlag, 1984

Number of active teaching classes	**Theoretical classes: 30**	**Practical classes: 30**

Teaching methods

Lectures, auditory exercises, independent student work

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**5**	oral exam	**30**
Practical classes	**65**		

Study programme: Bioengineering/Mechanical Engineering			
Course name: Computational Mechanics of Fracture and Damage			
Lecturer: Jovičić Gordana, Živković Miroslav			
Course status: Elective			
No. of ECTS: 6			
Precondition: None			
Course objectives The aim of the course is to enable students to estimate the integrity of structures applying methodologies based on fundamental postulates of fracture and damage mechanics. Introducing students with the basic parameters of fracture mechanics and dynamic parameters of materials which are determined experimentally.			
Course outcomes Acquiring basic knowledge about fracture and damage mechanics; Within the course, the basic principles of continuum mechanics in the stress analysis of structural components with initial cracks will be presented, using a finite element method. Structural analysis will be performed by implementing the finite element method.			
Course content *Theoretical classes* The concept of material fatigue. Damage occurrence caused by fatigue. Dynamic strength of a material. Failure criteria defining the onset of damage initiation in a material; Defining the onset of material failure applying the failure criteria; Failure criteria for isotropic materials; Failure criteria for anisotropic materials. Hill, TsaiWu, EPFS and GEPFS failure criteria. The importance of studying material fatigue in engineering practice; Crack initiation - Phase I, II, III of crack growth; Fatigue-crack growth laws; High-cycle fatigue-crack growth; Goodman's rule; Miner's rule of damage; Numerical examples of simulation of fatigue due to cyclic load; Analysis of fatigue using stress and strain approach; Damage accumulation theory. Basic parameters of computational fracture mechanics; Stress analysis around the crack tip; Stress intensity factor; Types of crack load I, II, III type of crack load, definition of K factor by applying a mixed load type; Relationship between K and G; Contour J integral; Application of J-EDI method. *Practical classes* Estimation of the structure integrity: a) due to fatigue, b) at the appearance of initial crack; Numerical simulation of fatigue-crack growth. Experimental determination of basic parameters of fracture mechanics - Fracture toughness, Maximum value of SIF; material fatigue-Dynamic endurance, Permanent dynamic endurance.			
Literature 1. Jovičić G., Živković M., Integrity and Lifetime of Structures (in Serbian), Faculty of Engineering in Kragujevac, ISBN 978-86-6335-022-9, 2016; 2. Sedmak A., Application of Fracture Mechanics to Structural Integrity (in Serbian), Faculty of Mechanical Engineering, Belgrade ISBN 86-7083-473-1; 2003; 3. Šumarac D., Krajčinović D., Fundamentals of Fracture Mechanics (in Serbian), Naučna knjiga, Belgrade;1990			
Number of active teaching classes	**Theoretical classes: 45**		**Practical classes: 30**
Teaching methods: Lectures, auditory exercises, laboratory exercises, consultations			
Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	/	written exam	**30**
Practical classes	**15**	oral exam	/
Colloquium(s)	**15**		
Seminar(s)	**40**		

Study programme: Bioengineering/Mechanical Engineering		
Course name: Computational Fluid Dynamics		
Lecturer: Filipović D. Nenad, Savić R. Slobodan		
Course status: Elective		
No. of ECTS: 6		
Precondition: None		
Course objectives The objective of the course is to introduce students to the fundamentals of computational fluid dynamics such as mixed, penalty and explicit formulation of solving the fluid field, finite element method, finite difference method, Taylor-Galerkin method for non-stationary fluid flow, UPWIND technique, TAYLOR-GALERKIN method and coupled solution of solid-fluid interaction problem.		
Course outcomes After they have mastered the programme and passed the exam within the course named Computational fluid mechanics, the candidates will be able to successfully follow the contents of the courses that relate to the area of calculation of physical fields, as well as to engage in research and scientific work in this new field. The knowledge that the candidates will acquire is related to the basic methods of numerical solving of fluid flow fields, coupled solving of the problem of solid-fluid interaction as well as parallel solving of large problems in fluid flow.		
Course content *Theoretical classes* Introduction and basic concepts in CFD. Mixed formulation (speed-pressures). Penalty formulation and explicit formulation. Numerical solving of fluid mechanics by using finite differences. Taylor-Galerkin's method for a non-stationary fluid flow. UPWIND technique in multi-dimensional space. TAYLOR-GALERKIN method. Coupled solving of solid-fluid interaction. Uncoupled solving of solid-fluid interaction. ALE formulation. Explicit - implicit algorithms (three-step). Turbulent models in CFD. Numerical problem solving of boundary layers. Numerical solving of compressive currents. Parallel processing in CFD. *Practical classes* Within the framework of the study research work, students will be trained to perform basic research in the subject area.		
Literature 1. Filipović N., ., Basics of Bioengineering (in Serbian), Faculty of Engineering, Kragujevac, 2012. ISBN 978-86-86685-66-7. 2. Kojić, M., Slavković, R., Živković, M., Grujović, N.: Finite Element Method I, Linear Analysis (in Serbian), Faculty of Mechanical Engineering, Kragujevac, 1998. 3. Bathe, K. J.: Finite Element Procedures in Engineering Analysis, Prentice-Hall, Inc., Englewood Clis, New Jersey, 1982.		
Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**
Teaching methods Lectures, auditory exercises, independent student work.		

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**5**	oral exam	**30**
Practical classes	**65**		

Study programme: Bioengineering
Course name: Biomedical Image Processing
Lecturer: Goran B. Devedžić
Course status: Elective
No. of ECTS: 6
Precondition: None
Course objective The course aims to introduce candidates to the fundamentals of creating biomedical images using different modalities, biomedical image processing in clinical settings, principles of image presentation and image storage, types of models, transformation, segmentation, registration and various applications of biomedical images.
Course outcomes After they have mastered the programme and passed the exam within the course entitled Biomedical Image Processing, the candidates will be able to engage in scientific research in this interdisciplinary field. The knowledge acquired will allow them to familiarize with the basic principles of biomedical image formation by applying ionizing and non-ionizing modalities, methods of transformation, principles of segmentation and registration, as well as by using software packages for this purpose. This will enable students to independently perform a real task in the field of application of the principles of creating and processing biomedical images.
Course content *Theoretical classes* Basic principles of biomedical image formation. Processing of biomedical images in clinical settings. Biomedical images presentation. Filtering and transformations. Segmentation. Rendering and surface models. Registration. *Practical classes* Practical problem solving in the area of formation and processing of biomedical images using software packages for this purpose and writing a seminar paper.
Literature 1. Wolfgang Birkfellner: "Applied Medical Image Processing: A Basic Course", CRC Press Inc., Bosa Roca, USA, 2014. 2. Isaac Bankman: "Handbook of Medical Image Processing and Analysis", Academic Press Inc., San Diego, USA, 2011. 3. Milan Sonka and Vaclav Hlavac: "Image Processing, Analysis, and Machine Vision, Cengage Learning, Inc., Florence, KY, United States.

Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**

Teaching methods Theoretical classes are taught interactively in a classroom. Practical classes are conducted by using computers.

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**10**	written and or oral exam	**40**
Practical classes	**10**		
Seminar(s)	**40**		

Study programme: Bioengineering			
Course name: Biomaterials			
Lecturer or lecturers: Fatima Živić, Dragan Adamović			
Course status: Elective			
No. of ECTS: 6			
Precondition: None			
Course objectives Introducing students to the basic classes of materials which are used as biomaterials for development of medical implants and devices.			
Course outcomes Students will learn how to recognize and select an appropriate material according to a clinical application of a medical implant or device. To understand the relationship between the composition, structure and properties of biomaterials as well as the primary physical, chemical and biological processes that occur in contact of tissue and biomaterial during its application. To understand the role and importance of certain biomaterials in tissue regeneration.			
Course content *Theoretical classes* Introduction. Fundamentals of material science. Properties of natural materials and artificial biomaterials. The relationship between biomaterials and tissues and required properties of biomaterials. Major groups of biomaterials: Metal biomaterials; Polymer biomaterials; Ceramic biomaterials; Composite biomaterials; Biomimetic materials; Smart materials; Nanomaterials in medicine; Materials for cultivation of contact surfaces of biomaterials. Areas of application of biomaterials: Hard tissue implants; Soft tissue implants; Pharmaceutical biomaterials. Disinfection and sterilization of biomaterials. Methods of production, construction and processing of biomaterials. Principles of Material Selection. Biomaterials: state and perspectives. Standards and legal regulations in the application of biomaterials. Ethical Aspects of Application in Clinical Practice. *Practical classes* Characterization and testing of biomaterials. Basic methods of testing biomaterials: in vitro, in vivo preclinical and in vivo clinical trials. Analysis of biomaterials and biomaterial requirements for certain medical applications. Practical training designed for students in order to be able to select individual biomaterials according to their function. Study research work and use of primary scientific sources and systematization of collected data, with the focus on practical clinical applications and development of biomaterials - practical case study.			
Recommended Literature 1. Raković, D., Usković, D., Editors: Biomaterials (in Serbian), Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Society for Testing Materials, Belgrade, 2010. 2. Zivic F., Affatato S., Trajanovic M., Schnabelrauch M., Grujovic N., Choy K-L. (Eds) Biomaterials in Clinical Practice - Advances in Clinical Research and Medical Devices, 2017, Springer Nature, ISBN 978-3-319-68025-5, http://www.springer.com/gp/book/9783319680248 3. Ratner, B.D., et al., (Eds) Biomaterials science - An Introduction to Materials in Medicine, Elsevier Academic Press, London, 1996.			
Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**	
Teaching methods Classes are conducted through lectures, auditory and laboratory exercises. It is compulsory to attend more than 70% of lectures and exercises. In class activity of students during the semester is evaluated (70 points) as well as the final exam (30 points). Points are gathered accumulatively. A student has the right to take the final exam if he or she scores more than 35 points during classes.			
Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final test**	**points**
In class activity	**10**	final test	**30**
Practical classes	**10**		
Colloquium(s)	**40**		
Seminar(s)	**10**		

Study programme: Bioengineering		
Course name: Tissue Engineering		
Lecturer: Nenad Grujović		
Course status: Elective		
No. of ECTS: 6		
Precondition: None		
Course objectives The aim of the course is to introduce students to the concepts, principles and applications of tissue engineering technologies in the field of bioengineering whose purpose is to regenerate and restore function to tissues and organs in the body that are damaged due to illness or injury.		
Course outcomes Acquiring basic skills and competencies for further specialization in the field of tissue engineering and regenerative medicine. Students will develop a research approach, analytical and communication skills necessary for their further professional development in the area of tissue engineering.		
Course content *Theoretical classes* • Introduction to tissue engineering through case studies. • Processes in cells and tissues and their coupling with materials and nanotechnology. Metabolism and transport of nutrients. Interaction of cells and extracellular matrix. • Techniques of making and designing a foundation for the growth of scaffold tissue. Additive production, laser, water jet, bioprinting, electrospinning. Materials, biocompatibility, development of new composite biomaterials. • Devices, construction and application in tissue engineering. 3D printers. Incubators, design and biological microambient for tissue growth. Bioreactors. • Modelling and simulation in the field of tissue engineering. Cell proliferation model in a scaffold. • Analysis of an example of regenerative medicine from clinical practice and literature. *Practical classes* • Scaffold development - tissue growth substrates. • Development, design of hardware and software modules of incubators, bioreactors, bioprinters and other devices in the laboratory for tissue engineering. • Simulations in the field of tissue engineering. Numerical models (FEM, finite differences). Simulation, optimization, parameter identification (Excel, Matlab). • Development of an individual application project in the field of tissue engineering.		
Literature 1. Principles of Tissue Engineering Ed. (Lanza, Langer, Vacanti). Teaching materials on the Moodle portal of the Faculty www.fink.rs. 2. Papers published in journals, selected chapters from books available on the Internet.		
Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**
Teaching methods Teaching with the use of material on the portal with direct individual support in the laboratory.		

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**Points**
In class activity	**10**	oral exam	**30**
Practical classes	**20**		
Colloquium(s)	**20**		
Seminar(s)	**20**		

Study programme: Bioengineering		
Course name: Biomedical Instrumentation and Measurements		
Lecturer: Mačužić Ivan, Todorović Petar		
Course status: Elective		
No. of ECTS: 6		
Precondition: None		
Course objectives Introducing students with the basic principles of functioning of the instrumentation used in biomedical research, selection of components and formation of measuring chains for adequate purpose, conducting measurements, acquiring and primary processing of obtained data.		
Course outcomes Students are trained to independently design and form simple measuring chains for biomedical research, conduct measurements, collect and process data. In this way, they will be able to conceptualize and perform laboratory and clinical biomedical research.		
Course content 1) Principles of functioning and basic elements of measuring chains for biomedical application 2) Biopotential and possibilities of its measurement 3) Biosensors and electrodes 4) Elements of biomedical instrumentation (amplifiers, registers, indicators) 5) Measuring action potential of the nerve cells - EEG 6) Measuring action potential of muscle cells - EMG 7) Measuring action potential of the heart muscle - ECG 8) Measuring electrodermal skin activity - EDA/GSR 9) Computer-assisted measurement, acquisition and data processing, software for measurement 10) Measuring force and pressure in biomedicine 11) Measuring blood pressure, heart rate and lung capacity 12) Ultrasonic measurements in biomedicine 13) Application of electromagnetic radiation for biomedicine measurements (X-ray and CT) 14) Nuclear magnetic resonance in biomedical research		
Literature 1. Dejan Popović, Mirjana Popović, Biomedical Instrumentation and Measurement (in Serbian), Nauka, Belgrade, 2009.		
Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**
Teaching methods Theoretical and practical classes		

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	/	oral exam	**30**
Practical classes	**20**		
Colloquium(s)	**50**		

Study programme: Bioengineering			
Course name: Design of Biomedical Devices			
Lecturer: Ivanović T. Lozica			
Course status: Elective			
No. Of ECTS: 6			
Precondition: None			
Course objectives The main goal of the course is acquiring knowledge in the field of design and development of medical devices, equipment and instruments. Understanding the principles of design and applying the innovation process as a framework for identifying important health needs and assessing the possibilities of designing medical devices for effective problem solving.			
Course outcomes A student who passes this course acquires the ability to creatively harmonize the factors from idea to innovative solution within the development of medical devices. They acquire the ability to search, collect and integrate knowledge, as well as the skills of a holistic, critical and systematic approach to the problem of design and development of a medical device. The students will be trained, in team work or independently, to design medical devices, with integration of appropriate legal regulations (FDA regulations, ISO 13485 Directive etc.).			
Course content *Theoretical classes:* Design definition. Contemporary concepts and philosophies in the field of designing. Basic concepts and goals in medical device design. Standards and legal regulations for medical devices and their application in designing of medical devices. The role and significance of the design methodology and process in the development of medical devices. Elements of the design process, with specific applications for biomedical engineering: problem identification, product conceptualization, design analysis, optimization, biocompatibility, health impact and patient comfort, regulatory requirements and medical ethics. Product design tailored to production, assembly and use. Functional, technological and ergonomic component. Aesthetic elements and principles of design. Natural forms and biological principles (biomimetics) and their influence on the development of medical devices. Application of creative methods in the development of medical devices. Generating new variants of conceptual solutions. Methods and tools for analysing the characteristics of variant solutions. *Practical classes:* Examples of the application of different types of regulations and standards in the field of medical device design. Independent student research, with the application of a critical approach, aimed at creating a medical device from the point of view of identified medical need, with the inclusion of other aspects (such as functional, ergonomic, production, economic, aesthetic and ecological). Testing and evaluating both the feasibility and the consistency of the solution, including the final design, according to the list of requirements, with the application of physical or virtual prototypes and the most appropriate validation methods. Consultations and discussions with students while working on improving the conceptual design of a medical device.			
Literature 1. ISO TC 210/ ISO 13485:2016, Medical devices -- Quality management systems -- Requirements for regulatory purposes, International Organization for Standardization, 2016. 2. Durfee W, Iaizzo P., Medical Device Innovation Handbook, Medical Devices Centre, University of Minnesota, Minneapolis, USA, 2015. 3. Fries R. C., Handbook of Medical Device Design, CRC Press, 2001. 4. Ivanović L., Kuzmanović S., Vereš M., Rackov M., Marković B., Industrial Design (in Serbian), Faculty of Engineering of the University of Kragujevac, Kragujevac, 2015.			
Number of active teaching classes	**Theoretical classes: 45**		**Practical classes: 30**
Teaching methods Teaching includes lectures and exercises, with independent student research. Throughout the semester, through colloquiums and seminar work, students' knowledge is regularly evaluated. Oral defense of seminar papers is mandatory.			
Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**5**	written exam and oral exam	**30**
Colloquium(s)	**30**		
Seminar(s)	**35**		

Study programme: Bioengineering

Course name: Ergonomics in Bioengineering

Lecturer: Jovanka Lukić

Course status: Elective

No. of ECTS: 6

Precondition: None

Course objectives

To understand complex work place requirements from anthropometric conditions, lighting conditions, microclimate, noise and vibrations.

Acquiring knowledge for: problem identification, finding solution and testing its efficacy from ergonomic perspective.

Course outcomes

After the module is completed, a student has the ability to:

- Identify basic parameters defining work position and work task
- Set basic parameters necessary for solving ergonomic issues
- Verify the suggested solution.

Course content

Theoretical classes

Introduction to ergonomics. Research methods. Designing and grading methods. Review and control. Defining work position. Work biomechanics. Cumulative damage and disorder. Stress and work load (physical and mental) of a driver. Safety and errors. Interaction person-surrounding. Comfort.

Practical classes

Methods of defining and estimating the impact of surrounding on work place comfort. Defining field of vision and controls positions applying the human model in CAD (Ramsis) surrounding.

Literature

1. Pheasant S.: Bodyspace: Anthropometry, Ergonomics and the Design of Work, Taylor & Francis, 2003
2. Kroemer K. H, Kroemer H, J, Kroemer-Elbert, K, E: Engineering Physiology, Bases of Human Factors, Engineering/Ergonomics, Springer-Verlag Berlin Heidelberg 2010
3. Human Solutions: Ramsis

Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**

Teaching methods

Classes are conducted through lectures, auditory and laboratory exercises and individual student work.

Knowledge assessment (maximum no. of points 100)

Pre-exam obligations	**points**	**Final exam**	**points**
Colloquium(s)	**40**	oral exam	**40**
Seminar(s)	**20**		

Study programme: Bioengineering
Course name: Communication Protocols Programming
Lecturer: Aleksandar Peulić
Course status: Elective
No. of ECTS: 6
Precondition: None

Course objectives

The objective of the course is to introduce students to communication protocols for connecting computer systems and to train them to design and implement modern communication protocols for transfer of data and management of information which are used in modern industry.

Course outcomes

After the course completion, students will be able to:

- Realise communication protocols, USART, RS422/485, USB, CAN, ModBus, Bluetooth, ZigBee
- Design and implement solutions on contemporary microcontrolling systems
- Demonstrate understanding of programme concepts, methods and approaches
- Demonstrate understanding of advanced concepts of data exchange and storage.

Course content

Theoretical classes

- Communication protocols
- Programming and protocol implementation
- Contemporary microcontrolling systems ARM core, Cortex

Practical classes

- Laboratory exercises on development surrounding Stm ARM Cortex M4, TI Stellaris ARM Coretex. Microchip PIC 18F4550

Literature:

1. Ball R.: Embedded Microprocessor Systems: Real Word Design, Third Edition, Elsevier, 2003, ISBN 978-0750675345
2. Data and Computer Communications (10th Edition) (William Stallings Books on Computer and Data Communications)
3. Pc interfaces, Vojo Milanovic, 2009

Number of active teaching classes	**Theoretical classes: 45**	**Practical classes: 30**

Teaching methods:

Classes are conducted through lectures, exercises and independent student work. The students will receive basic information during lectures. During exercises, the students will gain practical knowledge and skills regarding the use of specific tools from certain areas. The students will perform individual tasks which cover and integrate knowledge related to the use of certain tools.

Knowledge assessment (maximum no. of points 100)

Pre-exam obligations	**points**	**Final exam**	**points**
Colloquium(s)	**30**	written exam	**30**
Partial exam	**10**		
Seminar(s)	**30**		

Study programme: Bioengineering/Mechanical Engineering/Computer Techniques and Software Engineering
Course name: Artificial Intelligence
Lecturer: Vesna M. Ranković
Course status: Elective
No. of ECTS: 6
Precondition: None

Course objectives

Students are introduced to the basic concepts of intelligent systems. Experience is gained in the area of knowledge presentation, reasoning methods, system phase, neural networks and genetic algorithms. Areas of application are being studied in technics, medicine, economics and other. During exercises, examples will be analyzed, by use of appropriate programmes, from different areas of artificial intelligence application.

Course outcomes

Students will master basic principles of intelligent systems design and grading.

Course content

Theoretical classes

Fundamentals of artificial intelligence: mathematical logics, knowledge and reasoning. Artificial intelligence programme languages. Expert systems: knowledge presentations, reasoning methods. Expert systems design. Expert systems applications (decision, management, diagnostics, etc.). Fuzzy sets theory and approximate reasoning. Fuzzy sets definition and presentation. Operations on fuzzy sets. Fuzzy relations and operations on fuzzy relations. Linguistic variable. Fuzzy system structure. Examples of fuzzy system application. Neural networks. Neuron and neuron model. Artificial neural network architecture and learning. Single-layer perceptron. Algorithms for single-layer perceptron learning. Multilayer perceptron. Back propagation algorithm. RBF neural network. Recurrent neural networks. Hopfield network. Examples of neural network application. Genetic algorithms. Creation of initial population. Objective function. Selection. Recombination. Mutation. Application of genetic algorithms in optimisation. Artificial intelligence hybrid systems.

Practical classes

Classes are conducted in computer classroom. Prolog and MATLAB programmes are used.

Literature

1. Vesna Ranković, Artificial Intelligence (in Serbian), script, Faculty of Mechanical Engineering, Kragujevac, 2008.
2. Vesna Ranković, Intelligent Control (in Serbian), Faculty of Mechanical Engineering, Kragujevac, 2008.
3. Miroslav Jocković, Zoran Ognjanović, Stevan Stankovski, Artificial Intelligence, Intelligent Machines and Systems (in Serbian), Belgrade, 1997.

Number of active teaching classes	**Theoretical classes: 30**	**Practical classes: 30**

Teaching methods

Lectures, auditory exercises, laboratory exercises, independent student work.

Knowledge assessment (maximum no. of points 100)

Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**5**	oral exam	**30**
Colloquium(s)	**40**		
Seminar(s)	**25**		

Study programme: Bioengineering/Mechanical Engineering/Military Industrial Engineering

Course name: Advanced Analysis and Computer Simulation of Systems

Lecturer: Miroslav Živković

Course status: Elective

No. of ECTS: 6

Precondition: None

Course objectives

To understand theoretical basis of nonlinear continuum mechanics and its application in nonlinear analysis of structures using finite elements method. Introduction to the concept of static and dynamic nonlinear FEM analysis. Application of FEM in nonlinear analysis of real engineering problems.

Course outcomes

Upon passing the exam, students will be able to:

- understand theoretical basics of nonlinear continuum mechanics;
- understand basics of static and dynamic nonlinear analysis using finite element methods;
- apply gained knowledge on modelling and nonlinear analysis of real engineering problems.

Course content

Theoretical classes

Concept of geometrical and material nonlinearity. Fundamentals of nonlinear continuum mechanics. Lagrange and Eulerian description of motion. Reference and current configuration. Strain gradient, polar decomposition. Strain measures for large strain: left and right Cauchy deformation tensor, Green-Lagrange, Almansi strain tensor. Generalized strain measures, logarithmic strain. Velocity gradient and strain rate. Energy conjugate stress-strain measures; Cauchy, 2^{nd} Piola-Kirchhoff stress tensor. Constitutive relations. Linearization of equation of motion: Principle of virtual work and differential equation of motion. Total and updated Lagrange formulation. Linearization of equation of motion, linear and geometrical nonlinear stiffness matrix, mass matrix and internal forces vector. Incremental-iterative equilibrium equation. Solution methods for nonlinear equations in static analysis. Newton and modified Newton methods. Convergence criteria. Material nonlinearity: Integration of constitutive relations in incremental iterative solution procedure of displacement method. Isotropic metal plasticity and governing parameter method. Finite element matrix creation: Solid elements: 2-D and 3-D; structural elements: shell and beam elements. Definitions of geometrically nonlinear stiffness matrix for total and updated Lagrangian formulation. Improving finite elements using incompatible modes. Nonlinear dynamic analysis: Explicit integration. Implicit integration.

Practical classes

Determination of deformation gradient. Left and right Cauchy deformation tensor calculation. Principal directions and principal values of strain tensors. Determination of symmetrical elongation tensors and orthogonal rotation tensor. Calculation of Green-Lagrange and Almanasi strain tensors. Solving problems of geometrical nonlinearity and isotropic metal plasticity using PAK programme package.

Literature

1. Dunica Š, Kolundžija B: Nonlinear Structural Analysis (in Serbian), Faculty of Civil Engineering, Belgrade, 1986.
2. Živković M: Nonlinear Structural Analysis (in Serbian), Faculty of Mechanical Engineering, Kragujevac, 2006.

Number of active teaching classes	Theoretical classes: 30	Practical classes: 30

Teaching methods

Teaching is conducted through lectures, practical classes and independent student work. During lectures, students receive basic information. In practical classes, students gain practical knowledge and skills for using CAD and FEM tools. Students do homework independently.

Knowledge assessment (maximum no. of points 100)

Pre-exam obligations	points	Final exam	points
Colloquium(s)	**40**	oral exam	**30**
Seminar(s)	**30**		

Study programme: Bioengineering

Course name: Musculoskeletal Systems

Lecturer: Jovičić Gordana, Dunić Vladimir

Course status: Elective

No. of ECTS: 6

Precondition: None

Course objectives

The objective of this course is to train students to estimate integrity in structural-numerical analysis of musculoskeletal system using basic principles of fracture and fatigue mechanics. In order to design bioengineering structures such as: orthopaedic fracture fixators, joint prosthesis, oral and maxillofacial implants and fixators in an adequate way, it is necessary to understand the phenomena related to fatigue and fracture development. Material fatigue and damage accumulation is especially present in biomechanical systems with cyclic repetition of damaging process.

Course outcomes

Structural design, based on numerical methods, as well as estimation of fatigue and fracture resistance of the complex systems from the area of biomedical engineering. Special attention is dedicated to training in the estimation of damage accumulation, initialisation of crack, its widening and uncontrolled development leading to functional failure of the analysed structure.

Course content

Theoretical classes

- Biocompatibility and biofunctionality of: orthopaedic fracture fixators, joint prosthesis, oral and maxillofacial implants and fixators;
- ASTM and ISO standards for determining the characteristics of strength, fatigue and fracture in bioengineering; Strength of hard mineralised tissue;
- Cancellation criteria; accumulation of fatigue induced damage; dynamic durability; Definition of initial crack length; Estimation of structure tolerance to fatigue load; Simulation of crack development by application of fatigue criterion, multi-axes fatigue, Definition of fatigue safety factor; Definition of FI (failure index).
- Case studies – Examples of numerical analyses to fatigue and fracture of bioengineering structures; Examples of strength numerical analyses and estimation of implant integrity (artificial knee, artificial hip); e) Structural analyses to fatigue and fracture of hard-mineralised tissues fracture fixators (tiles, external fixators, intramedular wedges); f) Oral and maxillofacial implants – structural strength analyses.

Practical classes: They are conducted in computer classroom and imply project assignment.

Literature

1. Jovičić G, Živković M, Integrity and Lifetime of Structures (in Serbian), Faculty of Engineering in Kragujevac, ISBN 978-86-6335-022-9, 2016;
2. N. Filipovic, Basics of Bioengineering (in Serbian), Faculty of Mechanical Engineering of the University of Kragujevac, 2012
3. L.A. Pruitt, A.M. Chakravartula, Mechanics of Biomaterials Fundamental Principles for Implant Design, Cambridge University Press, 2011;
4. Jovičić G., Živković M., Vulović S., Computational Mechanics of Fracture and Fatigue (in Serbian), Faculty of Mechanical Engineering of the University of Kragujevac, 2011;
5. Suresh S; Fatigue of Materials, Cambridge Univ. Press,2nd ed.,2010;
6. Software instructions: PAK, ANSYS.

Number of active teaching classes	**Theoretical classes: 30**	**Practical classes: 30**

Teaching methods:

Lectures, auditory exercises, laboratory exercises, consultations.

Knowledge assessment (maximum no. of points 100)

Pre-exam obligations	**points**	**Final exam**	**points**
Practical classes	**15**	written exam	**30**
Colloquium(s)	**15**		
Seminar(s)	**40**		

Study programme: Bioengineering		
Course name: Nanomaterials in Bioengineering		
Lecturers: Fatima Živić, Dragan Adamović		
Course status: Elective		
No. of ECTS: 6		
Precondition: None		
Course objectives To introduce students to the basic classes of nanomaterials which are used in bioengineering, such as nanomaterials used for medical implants and devices, directed drug delivery, medical diagnostics.		
Course outcomes Students will be able to recognize and select a suitable nanomaterial according to its clinical application. To understand the relations between content, structure and properties of nanomaterials as well as basic physical, chemical and biological processes which occur in their contact with living tissue. To understand the role and significance of individual nanomaterials and their practical application in bioengineering as well as aspects of nanomaterial toxicity.		
Course content *Theoretical classes* Basics of nanotechnologies and nanomaterials. Nanotechnologies multidisciplinarity. Basic nanomaterials classes. Nano and micro coatings on medical implants as a functional layer for active role toward living tissue. Deposition of different nanoparticles. Nanofibres as strengtheners in alloys and composites with advanced biomaterials. Nano particles in medicine: gold, silver, iron, graphene, carbon nanopipes, ceramic nanoparticles. Possibility of new materials and structures design. Devices using electron ray, EBM. Devices using very precise lasers, PLD. Devices using electrical field. Electrospinning. Precise lithography. Electro-chemical methods, electrodecomposition, dealloying. Powder metallurgy, 3D printing. PVD sputtering technologies, magnetron sputtering, 3D moulds. Setbacks in practical clinical application. Nanomaterials: current state and perspectives. Standards and legislation in nanomaterials application. Ethical aspects of application in clinical practice. *Practical classes* Nanomaterials characterisation and investigation. Basic methods of nanomaterial investigation: in vitro, in vivo preclinical and in vivo clinical tests. Analysis of nanomaterials and relevant requirements for certain medical applications. Practical enabling of students to choose nanomaterials according to the function. Student research work and use of primary scientific sources and systematisation of gathered data, focused on practical clinical applications and nanomaterial development – practical case study.		
Recommended literature 1. Raković D, Uskokovic D, (eds.): Biomaterials (in Serbian), Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Society for Testing Materials, Belgrade, 2010. 2. Brabazon D., Pellicer E., Zivic F., Sort J., Baró M.D., Grujovic N., Choy K-L. (Eds) Commercialization of Nanotechnologies - A Case Study Approach, 2017, Springer Nature, ISBN 978-3-319-56978-9, http://www.springer.com/cn/book/9783319569789		
Number of active teaching classes	**Theoretical classes: 30**	**Practical classes: 30**
Teaching methods Classes are conducted through lectures, auditory and laboratory exercises. Presence to the lectures and exercises is obligatory to more than 70% of classes. In class activity of students during the semester is evaluated (70 points) as well as the final exam (30 points). Points are gathered accumulatively. The student has the right to take the final exam if he/she scores more than 35 points during classes.		

Knowledge assessment (maximum no. points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
In class activity	**10**	written (final) test	**30**
Practical classes	**10**		
Colloquium(s)	**40**		
Seminar(s)	**10**		

Study programme: Bioengineering	
Course name: Technical practice 2	
Lecture or lecturers in charge of Technical practice organisation: Nenad Filipović, Velibor Isailović	
Course status: Mandatory	
No. of ECTS: 6	
Precondition: Enrolment in Master's studies	

Course objectives

- To acquire practical experience during student stay in companies or other work environments in which student expects to realise his/her professional career.
- To recognise basic functions in business, production and technological system in the domain of design, development, production and research, as well as the role and task of graduated mechanical engineer in such business system.

Course outcomes

- Acquiring practical experience about methods of organization and functioning of environments in which student expects the application of the gained knowledge in his/her future professional career.
- Mastering ways of communication with colleagues and getting to know business information flow.
- Recognition of basic processes in the development and design of products and technologies, production, testing and maintenance, according to expectations of future professional competence.
- Making personal connections and acquaintances that may be used during the study period or in future employment process.

Course content

Theoretical classes

The course is realized through practical, independent work of the student.

Practical classes

Practical work implies stay and work in companies, institutes and organizations in which different activities connected to Bioengineering are performed. Selection of the subject area and the company or some other organization is conducted during consultations with the course lecturer. Student may conduct practical work in: production companies, design and consulting organizations, research organizations, organisations dealing with biomedical equipment maintenance, process engineering organisations, organisations performing research of biomedical equipment and some of the laboratories of the Faculty of Engineering. Practice may be also conducted abroad. During practical work, students must keep record of job descriptions, conclusions and observations. After practical work is conducted, students make a report in the form of the seminar paper on the given subject and defend it in front of the course lecturer.

Literature

As agreed with the course lecturer.

Number of classes if specified	**Other classes: 180**

Teaching methods

Lectures – general and via presentations, exercises – demonstrative and independent work.

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
Activity during Technical practice	**70**	oral (seminar defense)	**30**

Study programme: Bioengineering	
Course name: Study research work on the theoretical bases of Master's thesis	
Lecturer: Master's thesis mentor	
Course status: Mandatory	
No. of ECTS: 8	
Precondition: Enrolment in the 2nd semester of Master academic studies	
Course objectives Application of basic, theoretical, methodological, scientific-expert and expert-applicable knowledge and methods in solving concrete problems in the selected field. Within this part of Master's thesis, a student learns about the problem, its structure and complexity, and makes conclusions about possible solutions based on conducted analyses. Studying the literature, students are introduced with the methods developed for solving similar tasks and engineering practice in their solving. The objective of student's activities reflects in acquisition of necessary experience through solving complex problems and tasks and through identification of possibilities for application of previously acquired knowledge in practice.	
Course outcomes Students are qualified to independently apply previously acquired knowledge from different fields studied earlier, in order to analyse the structure of the given problem and to systematically analyse it with the aim of reaching the conclusions on possible directions for its solving. Through independent use of literature, students expand their knowledge from the selected field and study different methods and papers related to similar problems. Thus, students develop abilities to conduct analyses and to identify problems within the given subject. By application of acquired knowledge from different fields, students develop the ability to recognize place and role of an engineer in the selected field, need for cooperation with other professions and for team work.	
Course content *Theoretical classes* Course content is formed individually in accordance with the needs for completion of concrete Master's thesis, its complexity and structure. Student reads appropriate literature, final papers and Master's theses of students engaged in similar topics, conducts analyses in order to find a solution for concrete task defined by the assignment of Master's thesis. Part of course teaching is conducted through individual study research work. Study research also includes active monitoring of primary knowledge on thesis subject, organization and conduction of experiments, numerical simulations and statistical data processing, writing and/or reporting at conferences from specific scientific field to which the topic of Master's thesis belongs. *Practical classes* Exercises in computer classroom.	
Literature Journals, Master's thesis, publications from the given area.	
Number of active teaching classes	**Study research work: 240**
Teaching methods Master's thesis mentor gives student an assignment. The student is obliged to perform work in the framework of the given Master's thesis topic, using the literature proposed by the mentor. During Master's thesis production, the mentor may give additional instructions to the student, refer to specific literature and additionally guide the student in order to develop high-quality Master's thesis. In the framework of study research work, the student consults the mentor and, if necessary, other teachers dealing with the problems from the field of the study. Within the given subject, student conducts certain measurements, research, counting, surveys and other research and statistical data processing if this is anticipated by the Master's thesis task.	

Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	**points**	**Final exam**	**points**
		oral exam	**100**

Study programme: Bioengineering

Course name: Master’s thesis

Lecturer: Master’s thesis mentor

Course status: Mandatory

No. of ECTS: 10

Precondition: Master's thesis defense could not be performed until all the other exams are passed

Course content

Taking into account that Master's thesis is taken from one of the module courses that the student had passed during Master academic studies, and that it has to be a course from the field of bioengineering, the way the contents of this course are determined is obvious. The topic of Master's thesis is agreed between a teacher and a student. Generally, Master's thesis must combine at least two of the following fields: materials on learned and elaborated subject, student's own numerical calculation, experimental work and/or design, exclusively based on independent research study of the student, under direct guidance of the course lecturer.

Teaching methods

Master's thesis is independent student's work done in a written form, with instructions and consultations with a mentor. Student presents at least three hard-cover copies of Master's thesis to the course lecturer and one copy in electronic form to the Faculty library. The course lecturer in charge of Master’s thesis forms defense committee. Date and time of public defense are announced on the information board of the Faculty at least two working days before scheduled date of defense. The student's grade from this final exam is reported to the candidate right after the defense of the thesis, with corresponding explanation.

Knowledge assessment (maximum no. points 100)

Master's thesis defense grade is obtained as the average of the grades assigned by the members of the a Master's thesis committee. Master's thesis grade is the mean value of the grade for the written part and thesis defense grade, rounded to an integer value of 5 (five) to 10 (ten). Students who unsuccessfully defend their thesis will be assigned grade 5 (five).