DESCRIPTION/Syllabi of Curricula/Module

Short Name of the University/Country code Date (Month / Year)	DSEA Jan 2019
TITLE OF THE MODULE	**Code**
Regenerative engineering and design of optimal structures	**P11**

Teacher(s)	Department
Coordinating: Olexander Altukhov, PhD **Others:**	Department of Computer and Information Technology (CIT)

Study cycle (BA/MA)	Level of the module (Semester number)	Type of the module (compulsory/elective)
Master	2nd semester (first year) for Masters	compulsory

Form of delivery (theory/lab/exercises)	Duration (weeks/months)	Language(s)
Lectures, lab	8 weeks	Ukrainian / English

Prerequisites	
Prerequisites: Human anatomy and physiology, mechanics of solids, structure of polymers, proteins, polysaccharides, metals and non metal elements, atomic bonding.	**Co-requisites (if necessary):**

ECTS (Credits of the module)	Total student workload hours	Contact hours	Individual work hours
5	150	54	96

Aim of the module (course unit): competences foreseen by the study programme

Students should be able:
- to learn new methods and tools of analysis, modeling, design and optimization;
- to effectively use tools and methods for analysis, design, calculation and testing in the process of developing biomedical products and services;
- to conduct research and observations on the interaction of biological, natural and artificial systems (prostheses, artificial organs, etc.);
- to identify, formulate and solve engineering problems related to the interaction between living and non-living systems.

Learning outcomes of module (course unit)	Teaching/learning methods (theory, lab, exercises)	Assessment methods (written exam, oral exam, reports)
Knowledge: - to understand the requirements for biomedical materials and products from them, physical and mechanical properties of biomedical materials and to master methods for their identification and statistical processing. - to have basic ideas about bioinertness (biocompatibility), electroneutrality, non-toxicity, tribological characteristics of fatigue strength of materials used for implants. - to formulate tasks and perform strength calculations using CAE systems taking into account mathematical behavioral models for biomedical materials. - to have computer modeling skills in the design of biomedical equipment and implants in accordance with individual anatomical features of a person; to use this computer aided design system.	Work with the lecture notes as well as on the available fundamental subject literature	Knowledge test
Skills: -Ability to define, formulate and solve problems of a constructive nature related to the peculiarities of the patient‘s organism and appropriate medical remedies.	Lectures, labs, consultations	Active attendance of lectures, individual project and presentation

- Ability to identify and use the most appropriate medical prosthetics for each individual case. - Ability to perform an analysis of patient characteristics, determine the type of required bioprosthesis and characteristics for optimal biocompatibility with the patient‘s body. - Ability to select the most appropriate materials and technologies of the production of bioprosthesis. - Ability to use biomedical modeling knowledge to prepare a bioprosthesis model for 3D printing or milling techniques. - Ability to develop and implement software for creating and manufacturing hardware and implant elements in MCAD/MCAM packages, integrate with these systems, and work with 3D printers.		
Competences: Ability to perceive, understand, summarize, retain and apply the knowledge gained. Ability to apply knowledge in practical situations and conduct research at the appropriate level. Knowledge and understanding of the subject area of professional activity. Ability to use information and communication technologies. Ability to find, process and analyze information from various sources. Ability to learn new methods and tools for analysis, modeling, design and optimization. Ability to effectively use tools and methods for analysis, design, calculation and testing when developing biomedical products and services. Ability to conduct research and observations on the interaction of biological, natural and artificial systems (prostheses, artificial organs, etc.). Ability to identify, formulate and solve engineering problems related to the	Lectures, practical training, consultations	Individual project and presentation

interaction between living and non-living systems. Ability to apply basic computer software knowledge to the automated design of medical devices and systems. Ability to understand the principles of construction of modern automated control systems for the production of medical devices, their technical, algorithmic, information and software support.		

Themes	**Contact work hours**							**Time and tasks for individual work**	
	Lectures	Consultations	Seminars	Practiacl work	Laboratory work	Placements	**Total contact work**	**Individual work**	**Tasks**
Regenerative medicine and biotechnology in orthopaedics									
1.An overview of regenerative medicine. Scope of anatomy, physiology and basic terminology. Functional biomaterials for regenerative medicine. Introduction of the latest trends in smart natural biomaterials for regenerative medicine. Biocompatibility. Methods for testing and evaluating biocompatibility: In Vitro Testing, In Vivo Testing.	2				4		**6**	**12**	Study exam/ complete exercise
2. Modality of dental implants: dentures, subperiosteal, endosteal; Type of blade, root form, packaging and preparation of dental implants. Cardio implants, Ophthalmic implants, Vitreous Implants.	2				4		**6**	**12**	Study exam/ complete exercise
3. Bones and Joints: structure and function of skeleton, types of joints and their disorders. Orthopedic implants: Temporary fixation devices, fracture healing, restoraion of ligaments, ACL reconstruction	2				4		**6**	**12**	Study exam/ complete exercise

with the use of biological and synthetic materials, joint replacements: total hip replacement, total knee replacement, bone regeneration with recirculating material.									
Mechanical design methods for bio-mechanical engineering									
4. Virtual prototyping. Virtual prototyping is the basis of the e-Design paradigm. Product modeling and modeling by means of CAD/ CAE/ CAM integrated software.	2				4		**6**	**12**	Study exam/ complete exercise
5. Finite element modeling. Topological approach to decomposition. Geometry decomposition approaches. Grid-based approach. Mesh quality improvement. Basics of dental implant construction. Interface between bone and implant. Assumptions about detailed geometry of bone and implant. Material properties. Boundary conditions.	2				4		**6**	**12**	Study exam/ complete exercise
6. Physical prototyping. Systems of rapid prototyping (RP) based on solid freeform fabrication (SFF) technology (Jacobs 1994) produce physical prototypes of the structure for design verification. Machining with the help of computer numerical control (CNC) provides manufacturing both functional parts and molds or dies for mass production.	2				4		**6**	**12**	Study exam/ complete exercise
7. CNC machining. Machining operations of virtual manufacturing: milling, turning, and drilling, planning of the machining process. Contour generating for processing tools, visualization and simulation of machining operations and estimatation of	2				6		**8**	**12**	Study exam/ complete exercise

machining time. Convertion to CNC codes (M-codes and G-codes) for the production of functional parts as well as stamps or molds for production.									
8. 3D printing techniques in regenerative medicine. Definition and principles of 3D printing. 3D bioprinting technologies: inkjet bioprinting, pressure-based bioprinting, laser-based bioprinting. solenoid valve-based printing, acoustic inkjet printing. Biopriting for skin. Organic printing. Printing on cells, stem cells. 3D printing for orthopedic implants.	4				6		**10**	**12**	
Total of the basic part	**18**				**36**		**54**	**96**	

Assessment strategy	**Weight in %**	**Deadlines**	**Assessment criteria**
Written theory exam	40%	during the semester / exam	good response to the questions
Practical exam on a computer	60%	during the semester / exam	the work is done completely without mistakes or minor errors

Author	**Year of issue**	**Title**	**No of periodical or volume**	**Place of printing. Printing house or internet link**
Compulsory literature				
Atala, Anthony; Murphy, Sean V	2017	Regenerative medicine technology: on-a-chip applications for disease modeling, drug discovery and personalized medicine		CRC Press ISBN: 978-1-4987-1191-3
Srinivas D. Narasipura, Michael R. King	2012	Engineering Biomaterials for Regenerative Medicine: Novel Technologies for Clinical Applications		Springer-Verlag New York ISBN: 978-1-4614-1079-9

Kursad Turksen	2015	Bioprinting in Regenerative Medicine		Springer International Publishing ISBN: 978-3-319-21385-9
Lijie Grace Zhang,John P Fisher,Kam Leong	2015	3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine		Academic Press ISBN: 9780128006641
Kuang-Hua Chang	2015	e-Design. Computer-Aided Engineering Design		Elsevier ISBN: 978-0-12-382038-9
Jianping Geng, Weiqi Yan, Wei Xu	2008	Application of the Finite Element Method in Implant Dentistry		Springer ISBN 978-3-540-73763-6
Additional literature				
Gerald Brandacher	2015	The Science of Reconstructive Transplantation		Humana Press ISBN: 978-1-4939-2070-9
Melba Navarro, Josep A. Planell	*2011*	Nanotechnology in Regenerative Medicine: Methods and Protocols		Humana Press ISBN: 978-1-61779-387-5