Co-funded by the Erasmus+ Programme of the European Union

Розроблено в рамках проекту "Erasmus+ (CBHE) BioArt "Інноваційна мультидисциплінарна освітня програма зі штучних імплантів для біоінженерії для бакалаврів та магістрів"
Developed in the frame of project "Erasmus+ (CBHE) BioArt "Innovative Multidisciplinary Curriculum in Artificial Implants for Bio-Engineering BSc / MSc Degrees" (586114-EPP- 1-2017- 1-ES- EPPKA2-CBHE- JP).

DESCRIPTION/Syllabi of Curricula/Module

Short Name of the University/Country code **Date (Month / Year)**	**VNTU / UA** **February 2020**
TITLE OF THE MODULE	**Code**
Regenerative biomedical technologies in modern medicine Bioprinting and 3-D printing technologies in biomedical engineering (discipline - Regenerative Medicine and 3-D Printing for Biomedical Engineering)	

Teacher(s)	**Department**
Coordinating: As. Prof. Serhii Tymchyk, Ph.D. **Others:** Professor **Sergii Zlepko**, Doctor of Technical Sciences, Professor; Associate Professor **Inna Vishtak**, PhD, Associate Professor	Dep. for Biomedical Engineering

Study cycle **(BA/MA)**	**Level of the module** **(Semester number)**	**Type of the module** **(compulsary/elective)**
MA	2 semester	Variable

Form of delivery **(theory/lab/exercises)**	**Duration** **(weeks/months)**	**Language(s)**
Lectures, exercises, practical training, laboratory study	18 weeks / 4 months	Ukrainian, English

Prerequisites	
Prerequisites: Knowledge: basic knowledge of design, construction of biotechnical systems, construction of object models, processing of biomedical information. Skills: none Competences: none	**Co-requisites (if necessary):** none

ECTS (Credits of the module)	Total student workload hours	Contact hours	Individual work hours
7	210	72	138

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

Students should be able to:

- to develop a working hypothesis, to plan and set up experiments to test the hypothesis and achieve an engineering goal with the help of appropriate technologies, technical tools and tools;
- to create and improve the means, methods and technologies of biomedical engineering for research and development of bioengineering objects and systems of medical and technical purpose;
- analyze complex medical engineering and bioengineering problems and formalize them to find quantitative solutions using modern mathematical methods and information technologies;
- solve complex problems of biomedical engineering with application of methods of mathematics, natural sciences and engineering sciences;
- to study biological and technical aspects of functioning and interaction of artificial biological and biotechnical systems.

Learning outcomes of module (course unit)	Teaching/learning methods (theory, lab, exercises)	Assessment methods (written exam, oral exam, reports)
Knowledge: Producers gain extensive knowledge of the construction and use of appliances; systems development 3-D models; systems for manufacturing 3-D objects; application of artificial objects in biomedical engineering	Slides, lecture notes, suggested books and literature, personal reports, written papers	Written/oral exam, essays
Skills: Analyze, develop and apply 3-D models; produce 3-D objects; apply artificial objects in biomedical engineering	Lectures, working groups, individual work	Exercise and practical, lab. reports
Competences: Perform critical literature research on the subject, use the knowledge in practice, exchange notions, present the results	Working groups	Exercise reports and presentations

Themes	Contact work hours							Time and tasks for individual work	
	Lectures	Consultations	Seminars	Practical work	Laboratory work	Placements	**Total contact work**	**Individual work**	**Tasks**
Current trends and prospects for the development of regenerative medicine	3						**3**	**10**	To study and understand the questions: Terminology and content of regenerative medicine (RM). RM methods. The principles of RM. Achievements and problems of RM. RM technologies. Regenerative biomedical technologies for therapeutic use. Main factors influencing the RM industry. The human body signaling system. Mechanisms of regeneration in the human body.
Regenerative biomedical technologies in dentistry	3						**3**	**10**	To study and understand the questions: Dental implantology. Stages of implantation in dentistry. Implantation analysis and correction. Features of different implant systems. Basic techniques of directed tissue regeneration. Architectonics of bone. Morphology of biocompatibility of intraosseous implants. Determination of the number of implants for implantation isotopy
Features of the use of regenerative medicine in skeletal osteosynthesis	3						**3**	**11**	To study and understand the questions: Modern technologies of skeletal osteosynthesis. Osteosynthesis with axial compression Neutralizing osteosynthesis. Osteointegration of a bioactive implant in skeletal osteosynthesis. Additive implant manufacturing technologies.
Regenerative technologies in cosmetology and aesthetic medicine	3						**3**	**11**	To study and understand the questions: Hardware cosmetology: principles, approaches, types. 3D rejuvenation technology. Regenerative technologies for correction and enhancement of body aesthetics. Laser cosmetology. Types of lasers for cosmetology and the principle of their action. Advantages and disadvantages of laser cosmetology. Aluma Thermal Lifting Technology is a non-invasive skin

									rejuvenation technology. Ultrasound SMAS lifting and skin laser therapy. ELOS technology for skin rejuvenation. Fraction laser for correcting aesthetic and age defects.
Physiotherapy treatment and rehabilitation support for regenerative technologies	2						**2**	**11**	To study and understand the questions: Physical methods of diagnostics and treatment in dentistry and implantology: physiological substantiation, indications, contraindications. Continuous direct current equipment (galvanization, electrophoresis, electrical anesthesia). Low voltage and frequency currents (dyadinometry, amplitude). Devices for using high, ultra high, ultra high frequency alternating currents. Ultrasound. Phototherapy. Application of magnetic field of different frequency.
Interaction and biocompatibility of implants with biological tissues	2						**2**	**11**	To study and understand the questions: General patterns of the reaction of the jawbone to implant insertion. The influence of the type of implantable material on bone regeneration. Classification of implantable materials by biocompatibility and survival criteria. The influence of different methods of treatment of the implant surface on the reaction of the tissue. Interaction of epithelial tissue with implant material. Methods for determining implant biocompatibility.
3D printing for biomedical applications	3						**3**	**11**	To study and understand the questions: Classification of 3D printers. Types of 3D printing. Supplies for 3D printing. Bioprinting. 3D printing in biomedical engineering
Theoretical foundations of implantology	3						**3**	**11**	To study and understand the questions: Types of implantation. Types of implants. Classification of implants. Implant biocompatibility. Effect of biomaterials on bone regenerative capacity. Selection criteria for biomaterials for implants.
Features of orthopedic treatment when using 3-D technologies	3						**3**	**11**	To study and understand the questions: Implant biomechanics. The choice of prosthesis design. General

									Requirements for Dental Implants. Laboratory stages of making dentures after implantation. Prosthetics of non-permanent dentures with support for teeth and implants.
Bioprinting and 3-D printers in dentistry	3						**3**	**11**	To study and understand the questions: Implants designs. Advantages of 3D printing over conventional prosthesis manufacturing methods. GARDEN / SELF technology. EAER technology. 3D modeling of dentures. Advantages and disadvantages of 3D dental implantation. Making patterns and prostheses on a 3D printer.
Features of blood microcirculation in the gums before and after implant placement	3						**3**	**10**	To study and understand the questions: Assessment of blood microcirculation in gums. Correction of blood microcirculation after implant placement. Medical-technical and hardware-software studies of peripheral microcirculation of the bloodstream in the maxillofacial area. Individual medical-diagnostic complex for determination of blood microcirculation. Optoelectronic complex for determination of blood microcirculation in gums. Doppler method for the study of blood microcirculation.
Evaluation criteria for implants in dentistry and osteosynthesis	2						**2**	**10**	To study and understand the questions: Criteria for clinical evaluation of intra-bone implants. Criteria for hardware evaluation of implant placement quality. Assessment of blood microcirculation status by tissue blood flow level, intensity, coefficient of variation. Photoplethysmographic index as a criterion for aeration of inflammatory process. Methods of frequency-resonance analysis. ISQ implant stability factor.
Implantable telemedicine and systems	3						**3**	**10**	To study and understand the questions: Principles of construction of implantable telemetry systems. The base station module of the implantable system. Implantable telemetry module. Monitoring the status of dental implants. Wireless network implants monitoring technologies. Selection of

									information exchange channels for BTS.
Practical training				2 2 2 3			**9**		Influence of optical radiation on objects Application of 3-D scanners in biomedical engineering Development of a 3-D model for osteosynthesis Development of 3-D model of dental implant.
Laboratory work					3 3 3 6 6 3 3		**27**		Investigation and analysis of modes of influence of light radiation on an object. Use of lasers in biomedical engineering Research Regenerative Medicine Devices and Tools for Cosmetology and Aesthetic Medicine Production and analysis of 3-D object (osteosynthesis) by different technologies of 3-D printing. Production and analysis of 3-D object (dental implant) by different technologies of 3-D printing. Evaluation of implant status. Comparison of implants made with different 3-D printing technologies
Final exam									
Total	**36**			**9**	**27**		**72**	**138**	

-

Assessment strategy	Weight in %	Deadlines	Assessment criteria
Practical works attendance and exercise reports	20		Attendance and reports
Laboratory work and reports	20		Attendance and reports
Colloquium (theory control)	25		Test
Individual tasks	10		Essays and presentations
Final exam	25		Written/oral exam

Author	Year of issue	Title	No of periodical or volume	Place of printing. Printing house or internet link
Compulsory literature				
Kalaskar, Deepak M., ed.	2017	3D printing in medicine	ISBN 978-0081007174	Woodhead Publishing
D. I. Wimpenny, P. M. Pandey, L. J. Kumar	2017	Advances in 3D printing & additive manufacturing technologies	ISBN 978-981-10-0811-5	Springer
Bhatia, S. K., Ramadurai K. W.	2017	3D printing and bio-based materials in global health	ISBN 978-3-319-58276-4	Springer
Anthony Atala, Robert Lanza, (eds)	2011	Principles of Regenerative Medicine	ISBN 978-0-12-381422-7	Academic Press
Additional literature				
Rybicki, Frank J., and Gerald T. Grant	2017	3D Printing in Medicine	ISBN 978-3-319-61922-4	*Springer International Publishing*
Kim, K. J., Joukov, N. (Eds.).	2017	Mobile and Wireless Technologies	ISBN 978-9-81-10-5281-1	Springer
Anthony Atala Robert Lanza Tony Mikos Robert Nerem	2017	Principles of Regenerative Medicine	ISBN: 978-0-128-09880-6	Academic Press
David L Stocum	2018	Foundations of Regenerative Biology and Medicine	ISBN: 978-0-7503-1624-8	IOP Publishing Ltd
Jose A. Andrades	2013	Regenerative Medicine and Tissue Engineering	ISBN: 978-953-51-1108-5	IntechOpen

This project has been funded with support from the European Commission. This publication / communication reflects the views only of the author, and the Commission cannot be held responsibility for any use which may be made of the information contained therein.