APPROVED BY
Director of Institute of Non-Destructive Testing
_____ V.N. Borikov
«01» 09 2016

BASIC DISCIPLINE SYLLABUS

OPTICAL METHODS IN BIOLOGY AND MEDICINE

Field (primary curriculum): 12.04.04 "Biotechnical systems and technologies"

Training profile: Biomedical sciences and engineering

Qualification (degree): Master

Basic academic enrollment plan 2016 *(year)*

Year: 2, semester: 3

Number of credits: 3

Types of academic activities	Time resource
Lectures	*16*
Seminars	*8*
Laboratory classes	*24*
Classwork	*48*
Self-guided work	*60*
TOTAL, hours	*108*

Type of attestation: exam

Supporting subdivision: Department of Industrial and Medical Electronics, Institute of Non-Destructive Testing, TPU

Head of Department _____ Fedor A. Gubarev

Head of the Field _____ Gennadiy S. Evtushenko

Lecturer _____ Fedor A. Gubarev

2016

1. Place of course in the structure of the field

Course «Optical Methods in Biology and Medicine» refers to an optional interdisciplinary professional unit «Biomedical engineering » (ДИСЦ.В.М.1.2)

Course «Optical Methods in Biology and Medicine» is preceded by the following disciplines (PREREQUISITES):
ДИСЦ.В.М5 "Interaction of physical fields with biological object",
ДИСЦ.В.М3 "Biotechnical Systems and Technologies",
ДИСЦ.Б.М2 "Biophysical fundamentals of living systems".

The contents of «Optical Methods in Biology and Medicine» course sections are consistent with the contents of the disciplines studied in parallel (COREQUISITES):
ДИСЦ.В.М.1.1 "Biomedical sensors and signals".

2. Course learning outcomes

In compliance with the primary curriculum requirements, mastering the course is focused on developing the following competences (learning outcomes) in students, including in accordance with the Federal State Educational Standards:

Table 1

Learning outcomes to be achieved by studying this course

Learning outcomes (competences from the Federal State Educational Standards)	Learning outcomes					
	Code	Knowledge	Code	Skills	Code	Experience
LO 1 (ОПК-1, ПК-2)	K1.2	The principles of the system concept, which is based on the analysis and synthesis of biotechnical systems;	S1.5	To develop medical diagnostic, research and information systems and to optimize their structure;	E1.5	The methods of calculating the basic functional characteristics of biotechnical systems;
LO 2 (ОПК-1) (ОПК-2, ПК-2)	K2.2	Characteristics of biological systems as elements of measuring and control engineering systems;	S2.3	Formulate the tasks of realization of upcoming trend in biomedical and environmental engineering;	E2.2	Experience of methodological analysis of scientific research and its results.
LO 3 (ПК-1, ПК-2)	K3.2	Methods of diagnostics and forecasting used in biotechnological systems, hardware and software tools necessary for the researcher to the automated analysis of data of biome-dical experiments.	S3.1	Apply the methods diagnostic research;	E3.1 E3.2	Schemes of technical support of diagnostic and treatment process. Work with modern hardware and software of biotechnical systems research;

LO 4 (ПК-1)	K4.2 K4.3	Classification and structure of biotechnical systems and different types of technologies; Examples of realization of biotechnical systems and technologies of estimation, monitoring and control of state and behavior of living organisms;	S4.3 S4.4 S4.5	Apply the principles of the system approach to the analysis and synthesis of biotechnical systems and technologies; To develop the structure of medical diagnostic, research and information systems and to optimize it; To develop circuits, construction drawings and technical drawings of products.	E4.1	Methods of calculating the basic functional characteristics of biotechnical systems;
LO 6 (ПК-6)	K 6.1 K 6.2	Phases and stages of the life cycle of medical equipment; The problem of ensuring reliable operation of the hardware in terms of medical and biological organization;	S 6.1 S 6.2	Carry out the projects of technical support of biotechnical systems based on standard tools; Correctly use the legal framework and regulations of service and metrological support of medical equipment;	E 6.1 E 6.2	Use the skills of basic technological processes of service of medical equipment; Skills of application the reliability estimati on methods and medical equipment safety testing;
LO 12 (ОПК-4)	K12.1	Types of self-educational activity for a professional, personal, social and cultural development	S12. 1 S12. 2	Educate themselves to solve life's problems and achieve professional goals; used as a source of self-training.	E 12.1	Control of temporal, spatial, professional and social factors that affect the processes of self-study.

During the course, students will acquire general vocational and professional competences: ОПК-1, ОПК-2, ОПК-4, ПК-1, ПК-2, ПК-4, ПК-6.

3. Course structure and contents

Theory

Section 1. Fundamentals of optical methods

1.1. Introduction to optical methods of research
1.2. Fundamental optical properties of objects
1.3. Fundamental physical processes

Section 2. Coherent and incoherent light sources

2.1. Objects of laser exposure
2.2. Lasers for biology and medicine
2.3. Laser surgery and therapy
2.4. Incoherent Radiation Sources.

Section 3: Optical methods for studying biological tissues and bioliquids.
3.1. Optical Microscopy
3.2. Optical Tomography
3.3. Electronic Speckle Pattern Interferometry
3.4. Monitoring of Hidden Objects.

Practice

1. The calculation of the radiation power incident on the object at the given values of the beam divergence and atmospheric attenuation coefficient on the track of a given length.
2. The calculation of the radiation dose to the low-intensity therapy.
3. Calculation of the laser efficiency.
4. Measuring the divergence of the laser radiation.
5. Calculation of the emission wavelengths of the harmonics of higher orders for lasers.

Labs

Lab No 1. Study of optical fiber light transmission.
Lab No 2. Microscopic and endoscopic diagnostics.
Lab No 3. Basics of laser safety. A study of the operation principle and the parameters of the emission of a helium-neon laser.
Lab No 4. Solid-state laser and second harmonic generation.
Lab No 5. Measuring of laser beam parameters.
Lab No 6. Laser monitor.

As the consequence of mastering course «Optical Methods in Biology and Medicine», students must achieve the following results:

Table 2

Planned course learning outcomes

№	Result
CLO 1 (РД1)	To provide search, analysis of scientific and technical information according to the subject of the study, use the achievements of science, engineering and technology
CLO 2 (РД2)	To perform calculations and design of optical medical systems for diagnostics and therapy.
CLO 3 (РД3)	Perform setup, repair and verification of laser and light equipment for medical and biological research.

4. Organization and training materials for students' self-guided work

4.1. Types and forms of self-guided work

Students' self-guided work includes everyday and creative problem-oriented self-guided work (SGW).

Everyday self-guided work is focused on extending and reinforcing students' knowledge, developing practical skills and includes:

- working with lecture materials, looking for and overviewing literature and electronic sources of information in compliance with an individually predetermined course problem;
- advanced self-guided work;
- performing home tasks, home tests;
- studying topics meant for self-guided studying;
- getting prepared for laboratory work, practical exercises and seminars;
- getting prepared for control work and exam.

Creative self-guided work includes:

- searching, analyzing, structuring and presenting information;
- research work and taking part in students' scientific conferences, seminars and academic competitions;
- analyzing academic publications under topics predetermined by the professor.

4.2. Control of self-guided work

The results of self-guided work are to be assessed in the following way: control by the tutor, in particular, a procedure the presentation of individual tasks and the defence of laboratory work.

A feature of the present stage of the control improvement is the development of students' self-management skills of lesson learned, the ability to find their own mistakes inaccuracies, as well as ways to correct actions.

5. Means of current and interim assessment of course learning outcomes

Course learning outcomes are to be assessed by means of the following control procedures:

Table 4

Control procedures	Course learning outcomes
Control works / Tests	CLO 1 (РД 1) CLO 2 (РД 2) CLO 3 (РД 3)
Carry out and defense of labs	CLO 1 (РД 1) CLO 2 (РД 2) CLO 3 (РД 3)
Exam	CLO 1 (РД 1) CLO 2 (РД 2) CLO 3 (РД 3)

The following tools (assessment tools fund) are meant for assessing the course learning outcomes as part of control procedures:

- incoming control questions;
- control questions to be asked during practical exercises and labs;
- self-control questions;
- testing questions;
- questions to be asked during credit test/exam.

6. Course learning outcomes rating

During current and interim attestation, the course learning outcomes are to be assessed in compliance with the «Guidelines for current control over academic progress, interim and final attestation of students at Tomsk Polytechnic University» approved by Rector's order.

In accordance with the Course Progress Chart:

- current attestation (assessing the quality of mastering theoretical materials (answers to questions, etc.) and practical activity results (solving tasks, performing exercises, solving problems, etc.) is to be performed during the semester (assessed in credits (no more than 60 points), by the end of the semester students must collect at least 33 points);
- interim attestation (examination, points test) is to be performed at the end of the semester (assessed in points (no more than 40 points), students must collect at least 22 points at an exam).

The final rating is determined by adding together the points collected during current and interim attestation procedures. The highest final rating equals 100 points.

In compliance with the Term Project Progress Chart:

- current attestation (assessing the quality of mastering sections, etc.) is to be performed during the semester (assessed in points (no more than 40 points), by the end of the semester students must collect at least 22 points);
- interim attestation (project (paper) defense) is performed at the end of the semester (assessed in points (no more than 60 points), students must collect no fewer than 33 points following the defense results).

The final rating of term project (paper) implementation is determined by summing up credits collected during the current and interim attestation procedures. The highest final rating equals 100 points.

7. Courseware

Primary literature:

1. Hooker S., Webb C. Laser Physics. – Oxford: Oxford University Press, 2010. – 648 p.
2. Nonlinear Optical Systems. Principles, Phenomena, and Advanced Signal Processing / edited by L.N. Binh, D.V. Liet. – New York: Taylor & Francis CRC Press, 2012. – 451 p.
3. Biomedical Imaging: applications and advances [Electronic resource] / edited by P. Morris. – Amsterdam: Elsevier, 2014. Excess:

http://www.lib.tpu.ru/fulltext2/m/2015/science_book/Biomedical_Imaging.pdf
4. Laser Focus World. Periodical Journal, USA. Excess: http://www.laserfocusworld.com/index.html
5. Quantum and Optical Electronics / G.S. Evtushenko, F.A. Gubarev; Tomsk Polytechnic University. – Tomsk, TPU Publishing House, 2011.

Supplementary literature:

1. Biomedical Photonics. Handbook / Editor-in-Chief Tuan Vo-Dinh. – CRC Press, 2003. – 1787 p.
2. Choe R. Diffuse optical tomography and spectroscopy of breast cancer and fetal brain. A dissertation in Physics and Astronomy. – University of Pennsylvania, 2005. – 248 p.
3. Fundamentals of Physics (10 ed.) / edited by J. Walker, – Wiley, 2014. – 1450 p.
4. Ian M. Watt. The Principles and Practice of Electron Microscopy (2 ed.). – Cambridge University Press, 1997. – 500 p.
5. Sokal, Robert. Biometry. The Principles and Practice of Statistics in Biological Reseach / R. R. Sokal, J. Rohlf. - 4th ed. - New York: W. H. Freeman and Company, 2012. - 937 p.

Internet resources

1. E-learning course “Optical Methods in Biology and Medicine” by Gubarev F.A. http://design.lms.tpu.ru/course/view.php?id=1951
2. Personal web site of prof. Gennadiy S. Evtushenko http://portal.tpu.ru/SHARED/e/EVT
3. Personal web site of A/prof. Fedor A. Gubarev http://portal.tpu.ru/SHARED/g/GFADDTPU

Software: specialized software is not required.

9. Facilities required for the course

№	Name (computer classrooms, university laboratories, equipment)	Building, rooms, number of installations
1.	Auditorium	Building 16V, room 326
2.	Laboratory of Quantum Electronics Equipment: 1. He-Ne laser LG-05 2. DPSS lasers 3. Copper bromide laser 4. Power meter PD 300 5. High-speed camera FASTER HiSPEC1 6. Photodiodes DET 10A/M 7. Measuring tape 8. Set of lenses	Building 16V, room 325

	9. Set of color and gray filters 10. Optomechanical devises 11. Personal computer	

The syllabus is developed in compliance with the Primary Curriculum Standard of TPU in accordance with the requirements of the Federal State Educational Standard for the training field «12.04.04 Biotechnical systems and technologies" and profile "Biomedical Sciences and Engineering".

The syllabus is approved at the meeting of the Department of Industrial and Medical Electronics, Institute of Non-Destructive Testing: protocol № 10.16 as of 26/08/2016.

Author: Fedor A. Gubarev

Reviewer: Alexander A. Aristov