СПбГЭТУ «ЛЭТИ»
ПЕРВЫЙ ЭЛЕКТРОТЕХНИЧЕСКИЙ

MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA
federal state autonomous educational institution of higher education
"St. Petersburg State Electrotechnical University" LETI "named after. IN AND. Ulyanov (Lenin)" (St. Petersburg Electrotechnical University "LETI")

I approve:

Vice-Rector for Research

_____ Tupik V.A.

"____" _____ 2022

WORKING PROGRAMM

Of discipline

"Optical and Optoelectronic Devices and Complexes"

for the preparation of graduate students in a scientific specialty

2.2.6. – Optical and optoelectronic devices and complexes

Saint Petersburg

2022

DISCIPLINE STRUCTURE

Supporting Faculty:	FEL
Supporting department:	Photonics
Well	4
Semester	8

Types of occupations

Lectures

Independent work

Type of intermediate certification

Exam (semester)	8

Developer	Tarasov S.A.
Head od dep. of FOT	Tarasov S.A.
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DISCIPLINE ABSTRACT
«OPTICAL AND OPTOELECTRONIC DEVICES AND COMPLEXES»

It provides for the study of the physical foundations and principles of operation of optoelectronic devices and complexes. The role and prospects of using optical-electronic systems for various purposes are considered. The skills of designing and using radiometric, thermal imaging, lidar and other optoelectronic systems are being formed.

SUBJECT SUMMARY

"OPTICAL AND OPTOELECTRONIC DEVICES AND SYSTEMS"

The course covers the physical background and basic working principles of optoelectronic devices and systems. The goal and prospects of use of optoelectronic systems of various configurations are considered. The skills of designing and implementation of radiometric, thermal imaging, LIDAR and other optoelectronic systems are formed.

GOALS AND OBJECTIVES OF THE DISCIPLINE

1. The study of the classification, physical foundations and principles of operation of optoelectronic devices and systems (OES); the impact of the propagation environment on the operation of the ECO; sources and receivers of radiation in the OES; basic principles of scanning and scanning devices in ECO; modulation and demodulation methods; image analyzers; methods for filtering optical signals in OES; principles of construction and features of IPS for various purposes.

2. Formation of the ability to choose the types and designs of ECOs necessary for solving various problems, to carry out their calculation and design.

3. Mastering the skills of analyzing the physical processes underlying the work of the ECO

THE CONTENT OF THE DISCIPLINE

Introduction

The role of optical and optoelectronic devices and complexes in the development of science and technology. Prospects and trends in the development of optical and optoelectronic devices and complexes.

Section 1. FOUNDATIONS OF THE THEORY OF OPTO-ELECTRONIC DEVICES AND COMPLEXES

Topic 1. Classification and structure of optoelectronic devices and complexes

Generalized block diagrams of optical-electronic devices (OED). Basic definitions, principles of operation of the OEP. Classification of optical-electronic devices and systems. Comparison of optical-electronic devices with visual, optical and radio-electronic devices.

Topic 2Sources and receivers of optical radiation

The main types of radiation receivers used in optoelectronic devices. Parameters of radiation receivers. Characteristics of radiation receivers. Single-element coordinate (position-sensitive) and sweeping radiation receivers. Multielement radiation receivers.

The main types of sources of optical radiation. Parameters and characteristics of sources. Incoherent artificial emitters. Natural sources of radiation.

Modern lasers: operating principles, circuit diagrams, operating modes, parameters and characteristics.

Topic 3. Influence of the propagation medium of optical radiation on the operation of the ECO

Passage of optical radiation through the atmosphere and other media

General questions of propagation of radiation in the atmosphere. Absorption and scattering of radiation in the earth's atmosphere. Fluctuations in the transparency of the

atmosphere. Refraction of optical rays. Influence of the atmosphere on the contrast between the observed object and the background.

Topic 4. Scanning in optoelectronic devices

Purpose and role of scanning. Scanning methods. Parameters and characteristics of scanning systems. Types of scanning systems in regular searches. Mechanical and optical-mechanical scanning systems. Scanning with an electron beam. Scanning with mirrors, refractive elements, rotating wedges.

Topic 5. Image analyzers in optoelectronic devices

Appointment of image analyzers and their classification. Main parameters and characteristics of analyzers. Beam-splitting amplitude analyzers. Amplitude-phase analyzers. Phase analyzers of the image. Frequency analyzers. time-pulse analyzers. Analyzers based on analog semiconductor converters. Multielement radiation receivers as image analyzers.

Topic 6. Modulation and demodulation of signals in optoelectronic devices

Purpose, classification and features of radiation flux modulation. Demodulation of optical signals. General characteristics of signal modulation methods in optoelectronic systems. Amplitude, frequency, phase, amplitude-frequency, amplitude-phase, pulse modulation. Raster modulation. Electro-optical and other types of modulators. Space-time modulators. Structure and spectrum of the modulated radiation flux. Loss of signal power during modulation.

Topic 7. Signal filtering in optoelectronic devices

General information about the best methods for receiving signals in the presence of interference. Optimal filtering when detecting a signal against the background of interference. Spectral filtering. Spatial filtering in incoherent optical systems. Spatial filtering in coherent optical systems. Filtering signals in the electronic path. Optical correlation.

Topic 8. Energy calculations of optoelectronic systems

Criteria for the quality of optical-electronic devices. Generalized methodology for the energy calculation of the OEP. Calculation of fluxes and irradiances at the input of an optoelectronic device. Calculation of flow losses in optoelectronic system.

Topic 9. Adaptation in optoelectronic devices

General information about the application of adaptation in the OED. Sensitivity adaptation. Angular field adaptation. Adaptation of parameters of optical and spatial filters. Adaptive optoelectronic systems with compensation of phase distortions of the optical signal. Adaptation in large-sized optical systems.

Section 2. OPTO-ELECTRONIC SYSTEMS FOR DIFFERENT PURPOSE

Topic 10. Radiometric and thermal imaging systems

Block diagram of the radiometer. Basic energy ratios. Fundamentals of thermal imaging. Calculation of the threshold sensitivity and resolution of the thermal imager. Thermal imaging systems for various purposes.

Topic 11. Spectral and polarization instruments for studying the natural environment and natural resources of the Earth by remote sensing methods

Satellite spectrographs and spectrometers. Multispectral optical scanning devices. Modern optical-electronic systems for the study of natural resources. Polarizing devices for the study of outgoing radiation.

Topic 12. Laser ranging devices and lidar systems

Element base of laser location. Lidar schemes for various purposes

Conclusion

Prospects for the further development of optical-electronic systems and devices for remote sensing of the natural environment.

If the discipline is implemented in groups with a small number, classes in individual sections can take the form of orientation lectures, the issuance and explanation

of the task on the topic, and the current control can take place in the form of presentation and defense of the completed task by the postgraduate student.

General recommendations for the completion of individual tasks are available to the graduate student in printed or electronic form (on the University website), or the graduate student can receive recommendations from the teacher responsible for the discipline during consultation hours. The task is formulated taking into account the topics of the PhD student's dissertation research within the framework of the discipline under study.

EDUCATIONAL AND METHODOLOGICAL SUPPORT OF DISCIPLINE

Methodological recommendations for the implementation of the discipline

Methodological recommendations for teachers:

Before starting to teach the discipline, the teacher must:

– know the goals and objectives of teaching the discipline;

– imagine what knowledge, skills and abilities a graduate student should acquire in the process of studying this discipline;

– to clearly understand in the formation of what results of mastering the postgraduate program the discipline is involved.

If the curriculum for the discipline provides for an exam, it is recommended to conduct it in the form of an individual conversation with a graduate student on the questions formulated in the funds of the discipline's assessment tools, using questions from various sections of the discipline, thereby ensuring a more complete test of the graduate student's knowledge.

In his activities, the teacher must be guided by local regulations governing educational activities in educational programs for the training of highly qualified personnel at the university.

Methodological recommendations for independent work of graduate students:

The study of each discipline should be accompanied by independent work of a graduate student with literature sources and Internet information resources recommended by teachers in all sections of the discipline.

A number of issues to be studied as part of the discipline are quite well developed in the educational literature, presented in scientific papers, collections of papers, articles, and on the Internet. These questions can be transferred to graduate students for independent study. Such work is built on the basis of tasks prepared by the teacher with a list of questions to which the student must find answers in the process of self-study. Both whole topics and individual questions can be studied independently as part of the topics indicated by the teacher, but not fully disclosed by him. To consolidate the material, notes are taken, abstracts, essays are prepared or reports are made. The degree

of mastering independently studied materials is necessarily checked by control measures using the fund of evaluation tools for the discipline.

A special place should be given to counseling as one of the forms of training and control of independent work. Counseling involves a specially organized interaction between the teacher and graduate students, it is assumed that the consultant either knows a ready-made solution that he can prescribe to the consulted person, or he owns methods of activity that indicate the way to solve the problem.

List of basic and additional educational literature, necessary for mastering the discipline

No.	Title, bibliographic description	Number of copies in the Bible (at the cafe)
1	Yakushenkov Yu.G. Theory and calculation of optoelectronic devices: Proc. for universities - 5th ed. – M.: Logos, 1999	10
2	Yu.B. Parvulusov, S.A. Rodionov, V.P. Soldatov and others. Designing optoelectronic devices: textbook. for universities; Ed. SOUTH. Yakushenkova - 2nd ed. - M .: Logos, 2000.	4
3	Tarasov V.V., Yakushenkov Yu.G. Infrared viewing systems. – M.: Logos, 2004	17
4	Miroshnikov, M. M. Theoretical foundations of optical-electronic devices: a tutorial / M. M. Miroshnikov. - 3rd ed. - St. Petersburg: Lan, 2021	EBS DOE
5	Buznikov A.A., Pozdnyakov D.V. Development and design of optical-electronic systems: Uch. settlement - SPb.: SPbGETU, 1997.	42

The list of resources of the information and telecommunication network "Internet" used in the development of the discipline

No.	Email address
1	Rodionov S.A. Electronic textbook on the course "Fundamentals of Optics" http://aco.ifmo.ru/el_books/basics_optics/
2	Ivanova T.V. Introduction to applied and computer optics. Lecture notes. http://aco.ifmo.ru/el_books/introduction_into_specialization/

Information technologies (operating systems, software for general and specialized purposes, as well as information reference systems) and the material and technical base used in the implementation of the educational process in the discipline comply with federal state requirements.

Specific forms and procedures for current knowledge control and intermediate certification, including a list of examination questions (Appendix 1), as well as guidelines for students on independent work when mastering disciplines, are brought to the attention of students in the first lesson.

Annex 1

List of exam questions by discipline

"Optical and Optoelectronic Devices and Complexes"

1. Optoelectronic devices: definition, generalized schemes and methods of work. OEP classification.
2. Physical principles for choosing the operating spectral range of the OES. The choice of radiation receiver.
3. OEP optical system. Purpose and features of the OED optical system.
4. optical filters. Absorption, interference, polarizing, neutral filters and attenuators.
5. Basic parameters and characteristics of emitters. The laws of thermal radiation.
6. Parameters and characteristics of radiation receivers. The main types of radiation receivers used in OED.
7. Spectral matching of the receiver and radiation source.
8. OED image analyzers. Purpose and classification.
9. Phase and frequency image analyzers. Beam-splitting amplitude analyzers. Amplitude-phase analyzers.
10. Scanning in OEP. Scanning methods.
11. Modulation and demodulation of signals in OED. Amplitude, frequency and phase modulation.
12. Generalized methodology for the energy calculation of the OEP.
13. Energy calculation of the OES operating by the passive method.
14. Energy calculation of the UES operating by the active method.
15. Optoelectronic tracking systems.
16. Radiometric and thermal imaging systems. Block diagram of the radiometer. Basic energy ratios.
17. Fundamentals of thermal imaging. Threshold sensitivity and resolution of the thermal imager.
18. Polarimeters. Purpose and scope. Stokes parameters.

19. Modern OES for the study of natural resources of the Earth.
20. Satellite spectrometers.
21. The main directions of development and use of the ECO.