File Ref.No.Ac.A3/Faculty of Engineering/2022

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Engineering - Regulations and Syllabus of Dual Degree Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE) offered by Division of Electronics and Communication Engineering, School of Engineering, CUSAT and Saint Petersburg Electrotechnical University "LETI", Russia - Academic Council Resolution - Orders issued

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ACADEMIC A SECTION

No.CUSAT/AC(A).A3/31/2024 Dated,KOCHI-22,30.12.2023

Read:-Item No. I (c) of the minutes of the meeting of the Academic Council held on 15.12.2023

ORDER

The Academic Council vide item read above considered along with the recommendations of its standing committee, the Minutes of the Faculty of Engineering and resolved to approve the Regulations (Appendix I) and Syllabus (Appendix II) of **Dual Degree Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE)** offered by Division of Electronics and Communication Engineering, School of Engineering, Cochin University of Science and Technology and Saint Petersburg Electrotechnical University "LETI", Russia, with effect from the academic year 2024-25.

Orders are issued accordingly.

Dr. Meera V *
Registrar

To:

1. The Dean, Faculty of Engineering
2. The Chairmen of all BoS under the Faculty of Engineering
3. AR/DR Exams / The Director, DoA
4. PS to VC/PVC;PA to Registrar/CE.
5. WebMaster, CIRM.

* This is a computer generated document. Hence no signature is required.

Regulations for the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE) offered by Division of Electronics, School of Engineering, CUSAT and Saint Petersburg Electrotechnical University "LETI", Russia

SCOPE:

The following regulations are made applicable to the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE) offered by Division of Electronics, School of Engineering, CUSAT and Saint Petersburg Electrotechnical University "LETI", Russia with effect from the academic year 2024-2025. This programme aims to enhance the exchange of students between CUSAT and LETI by providing students with valuable educational opportunities to obtain degrees from both universities.

The programme is an opportunity for CUSAT to set a benchmark on quality of Master programme at an international level. The programme focuses on microelectronics and semiconductor technology which is highly relevant to our country. Indian government has implemented 'India Semiconductor Mission (ISM)' as a specialized and independent Business Division within the Digital India Corporation that aims to build a vibrant semiconductor and display ecosystem to enable India's emergence as a global hub for electronics manufacturing and design. This initiative by the Indian government is attracting semiconductor industries to our country demanding graduates specialised in microelectronics and semiconductor technologies.

DEFINITION:

Dual degree programme shall be a programme jointly designed and offered by CUSAT and Indian/foreign Higher Educational Institutions in the same disciplines/subject areas and in the same level. The degrees for such programme shall be conferred by CUSAT and India/foreign Higher educational institutions, separately and simultaneously, upon completion of degree requirements of both the institutions. This shall not in any way be

construed as two degree programmes in separate disciplines/subject areas and/or levels being pursued simultaneously.

1. Dual Degree Masters Programme

The Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE) offered by the Division and LETI shall be of four semesters duration spanning over a period of two academic years; wherein the first three semesters will include Lectures, Lab work, Practice, Research Coursework, Unsupervised Work, Interdisciplinary project and Internship (Research Project & pre-masters internship). The student will devote the fourth semester on a project (Graduate Qualifying Work) related to a relevant area of the specialization either in the Department / School or in an industrial / research / academic institution outside the University.

The programme allows students from each Institution to complete a part of their studies abroad, thereby enhancing their academic career within an international context, improving their command of a foreign language, and gaining valuable experience from both a personal and professional perspective.

Students enrolled in the Dual Degree Masters Programme will enroll and study at both institutions according to the curriculum and mobility plan. Each student admitted shall be assigned a Unique Registration Number by the department concerned in a format prescribed by the university, which will be valid throughout his/her programme of study in the University. Students enrolled at both institutions will complete first & second semesters at home university and third & fourth semesters at host university. Upon successful fulfillment of the program and all degree requirements at each institution, the students from LETI and CUSAT will be granted academic degrees from both institutions. Students who exclusively enroll at CUSAT without participating in studies at LETI will only receive a degree from CUSAT.

Subject to a mutual evaluation of the partner institution's standards for accreditation by both Parties, some of the credits earned from CUSAT / LETI will be accepted as equivalent to those attained through agreed/selected courses offered by CUSAT / LETI.

1.1 Branches of Study / Specialization

Sl. No.	Branch of study /specialization	Department / Division / School offering the programme	Full time / Part time
1.	Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE)	Division of Electronics, School of Engineering & Saint Petersburg Electrotechnical University "LETI", Russia	Full time

A student is admitted to the course as per the eligibility criteria prescribed below:

1.2. Eligibility for admission

1.2.1 The specific eligibility criteria for the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE) are given below.

i) Shall have passed B.Tech/ BE/ AMIE/ AMIETE Degrees in Electronics & Communication / Electrical and Electronics / Electronics and Instrumentation / Applied Electronics and Instrumentation branch or M.Sc in Physics/ Photonics / Electronics from any University in Kerala or an Examination of any other University/Institution accepted by this University as equivalent thereto with a minimum of 60% marks or 6.5 CGPA on a scale of 10.

ii) Both institutions guarantee that their candidates selected for Dual Degree Masters Programme will be deemed to be of an appropriate caliber and will possess appropriate academic and linguistic qualifications. Applications are evaluated first by the home institution and then presented to the partner institution for review and approval. To be admitted to the Dual Degree Masters Programme, students must meet all relevant admission policies at both institutions.

iii) CUSAT students seeking fee waivers for their third and fourth semesters of study in Russia must submit their program applications during the period from mid-November to December of their final year of qualifying degree at CUSAT. If numerous students are requesting for fee exemption, the selection criteria will depend on academic achievement or may be periodically decided.

1.2.2 Sponsored Candidates must have a minimum experience of three years in the relevant field and must be sponsored by University or Industry/Teaching/Research Organizations of Centre/State Government/or by Private Engineering Colleges approved by AICTE. Maximum age of sponsored candidates is fixed as 40 years as on 1st of August of the year of admission. Also, a special fee equivalent to the contingent grant received for GATE qualified candidates will be levied on the sponsored candidates.

1.2.3 The maximum number of students for the Dual Degree Masters Programme to be exchanged under the fee waiver scheme is 5 per year for each institution. As a general rule, the Parties will endeavor to exchange the same number of students in both directions.

Students enrolled in Dual Degree Masters Programme will be enrolled at both institutions, and will be entitled to the facilities and services offered by both institutions. They will begin graduate study at each institution in the same term. Students will be subject to all relevant regulations, codes of practice and procedures at both institutions, and will confirm their agreement to abide by those terms upon registration at each institution. Students opting for CUSAT degree alone, will be bound by CUSAT regulations only.

1.3 Course Structure

1.3.1 The course content of Dual Degree Masters Programme shall consist of Lectures, Lab work, Practice, Research Coursework, Unsupervised Work, Interdisciplinary project, Internship (Research Project & pre-masters internship) and project (Graduate Qualifying Work).

1.3.2 The curriculum for the first three semesters shall generally consist of Lecture, Lab work, Practice, Research Coursework, Unsupervised Work, Interdisciplinary project and Internship (Research Project).

1.3.3 Each theory course will carry two or three credits and Internship and Research Project of second and third semesters will have a total of 3 and 2 credits respectively.

1.3.4 Research project phase II and Execution & Defense of the project (Graduate Qualifying Work) in the fourth semester will have 12 and 3 credits respectively.

1.3.5 The minimum number of credits to be earned by a student for the award of the Dual Degree Masters Programme shall be 72 (equivalent to CUSAT) subject to the condition that the candidate successfully completes all the core and elective courses prescribed by the Department / School.

1.3.6 Students enrolled in a Dual Degree Masters Programme are expected to complete all required coursework, research project, research report, dissertation and any other work necessary subject to the rules and regulation set by both CUSAT and LETI to satisfy the requirements of his or her master's program at both Universities.

1.3.7 Students who complete the requirements will be awarded degrees separately by both universities, in accordance with the relevant regulations in force in each country and based on the conditions established by the two Parties for students of the Dual Degree Masters Programme.

1.3.8 English will serve as the medium of instruction for teaching in both institutions.

1.3.9 In the case of online courses attended by the student, a certificate of satisfactory completion and marks/ grade if any issued by the authority who conducted the course must be submitted to the Head of the Department. The Department can conduct a viva on the subject of the online course if necessary. On the completion of this, the department council can award the respective weightage/grade to the student as per CUSAT regulations.

1.3.10. A concise academic schedule is outlined below for the Dual Degree Masters Programme.

Semester	Timeline
I	July to December (At CUSAT)
II	January to April (At CUSAT)
III	May to December (At LETI) July to December (At CUSAT)
IV	January to June (At LETI / CUSAT)

1.4 Mode of Evaluation

1.4.1 A student would be considered to have progressed satisfactorily at the end of a semester if he/she has a minimum of 75 % attendance. The evaluation is completely internal.

1.4.2 Supervisory Committee-

A supervisory committee, composed of the Head of the host department (Chairman of the committee), a faculty coordinator from ETU LETI (Convener of the committee), the Director of International Relations, and one coordinator each from Division of Electronics Engineering, SOE, the Department of Electronics (DOE), and the Department of Physics and Department of Instrumentation, will be established to assess and oversee the students' progress throughout their term at both institutions. The committee must ensure that all academic and qualifying criteria from both institutions have been satisfied so that degrees can be separately and simultaneously be granted.

1.4.3 The student shall be evaluated continuously throughout the semester and marks shall be awarded on the basis of tests / assignments as detailed below:

A maximum of 20 marks are awarded for the various assignments/lab work/practices given to the students by the concerned faculty.

There shall be two class tests and an end semester examination.

The first class test carries 20 marks and will be based on the portions of the syllabi covered till then.

The second class test also carries 20 marks and will be based on the portions covered till then after the first class test.

The end semester examination will be for 40 marks and shall contain questions from the entire syllabi of the course.

The duration of the end semester examination shall be of three hours.

1.4.4 The results of each course in a semester shall be finalized by the concerned faculty member within 10 days from the last date of the end semester examination and the marks and grades obtained by the candidate in each subject shall be displayed on the notice board with the approval of the course-coordinator and head of the division/ department / school concerned.

1.4.5 The pass minimum in a course is 50%, with a separate minimum of 45% for end semester examination. If a candidate fails to secure 50% marks, he/she shall be deemed to have failed in the course.

1.4.6 Those who fail in any course shall approach the teacher concerned if necessary, for a re-examination of the semester end examination. Within ten days of the display of the results in the notice board, the department shall conduct an additional semester end examination for these candidates. This re-examination is only to provide the student a chance to pass the examination by completing the course successfully. If he/she completes the course successfully making use of this additional chance, he/she will be awarded only a 'D' grade enabling the candidate to be declared successful in that course. If he/she cannot make it up, he/she may repeat the semester end examination of that course along with the subsequent batches, or re-register and repeat the course. In this case he/she will be awarded whatever grade he/she has secured.

1.4.7 A pass in the course will entitle the student to acquire the number of credits allotted for that particular course. (for the details of number of credits, please refer to the course structure.)

1.4.8 A student shall acquire a minimum of 39 credits in the first two semesters before he/she can continue the programme at LETI for third and fourth semesters. A student shall complete the Dual Degree Masters Programme in 8 (eight) consecutive semesters in the case of full time programme by acquiring the minimum total credit requirement of 72.

1.4.9 Project evaluation shall be done at the end of III and IV semesters.

The evaluation at the end of III Semester shall be conducted by an examination committee consisting of the head of the department / school / division, a senior teacher nominated by the head and the project guide.

At the end of Semester IV, the students will have to submit a dissertation on his / her project (Graduate Qualifying Work). The dissertation shall have to be submitted as per the guidelines given in Appendix I.

Three bound copies along with a soft copy of the dissertation shall be submitted to the Head of the Department/School within the last date prescribed by the Department / School for the purpose.

1.4.10 The dissertation will be evaluated by an examination committee consisting of the head of the department / school / division, another senior teacher of the department/school /division concerned nominated by the Head of the Department / School, and the project guide. However, an external examiner may also be included in the examination committee with the approval of the Department / School Council. The candidate shall make an open defence of his/her dissertation which will be followed by a viva-voce examination.

Completion of the dissertation requires a defense at both institutions, with an in-person defense at the home university and an online defense at the host university, in order to qualify for the dual degree.

1.4.11 For the purpose of assessment, the performance of a student in the project dissertation may be divided into the following sub components:

At the end of III semester

Assessment by the project guide (based on periodic assessment of the work of the candidate) - 50%
Assessment by the examination committee - 50%

At the end of IV semester

Assessment by the project guide (based on periodic assessment of the work of the candidate) - 50%
Assessment by the examination committee - 50%

1.5 Classification

The following grading system is adopted for all the courses. The following grades will be awarded based on the overall performance in each course.

Range of Marks	**Grades**	**Weightage**
90 % and above	S- Outstanding	10
(80-89)	A- Excellent	9
(70-79)	B-Very Good	8
(60-69)	C- Good	7
(50-59)	D- Satisfactory	6
Below 50%	F- Failed	0

Overall performance at the end of the semester will be indicated by Grade Point Average (GPA) calculated as follows:

$$GPA = \frac{G1C1 + G2C2 + G3C3 + \text{----------} GnCn}{C1 + C2 + C3 + \text{----------} Cn}$$

Where 'G' refers to the grade weightage and 'C' refers to the credit value of corresponding course undergone by the student.

At the end of the final semester, Cumulative Grade Point Average (CGPA) will be calculated based on the above formula.

Classification for the Degree will be as follows:

Classification	**CGPA**
First class with distinction	8 and above
First class	7 and above
Second class	6 and above

2. Declaration of Results

An examination committee consisting of the Head of the Department (Chairperson), a senior teacher/Head of the Division concerned and the Course Coordinator shall scrutinise the marks and grades obtained by the candidates and finalise the results. The examination committee will be constituted by the Head of the department/school.

The grades and credits achieved in the third and fourth semesters at LETI will be communicated to CUSAT through credit transfer. This information will then be tabulated alongside the results of the first and second semesters conducted at CUSAT. The final marks will be reported to the University for tabulation and declaration of results. The University shall issue mark lists at the end of each semester.

2.1 Review of Question Papers and Valuation of answer books

At the end of each semester, the question papers set for class tests and end semester examinations will be reviewed by the Department / School Council of the host/home university. The review report may be placed in the Board of Studies concerned for scrutiny.

2.2 Grievance Cell

The Departmental / School Council or a subcommittee nominated by the Council will act as the grievance cell for the redress of complaints from the students on the conduct of the class test, semester exam, and the valuation methodology. The student shall make such complaints to the Head of the Department / School within a week of the display of the marks/grades for a particular course on the Notice board of the Department / Division.

3.0 Leave for a Dual Degree Masters Programme student with fee waiver/assistance

3.1 A full time student shall be entitled to the following kinds of leave during every academic year, counted from the date of commencement of the session concerned as prescribed in the academic calendar of the institute.

3.2 Any absence over and above the prescribed type of admissible leave shall entail deduction from the scholarship, beside other action as may be decided by the University.

Sl.No.	Leave	Maximum number of days	Sanctioning authority
1.	Casual Leave	5 days per semester subject to the condition that such leave will not be allowed for more than 3 days at a time. Casual leave cannot be combined with medical leave.	Head of the Department / School
2.	Medical Leave	3 days per semester	Head of the Department / School on the basis of a Medical Certificate from a registered Medical Practitioner certified by the University Medical Officer.

4.0 Revision of Regulation and Curriculum

The University may from time to time, revise, amend or change the regulations, schemes of examinations and syllabus. In the case of students already undergoing the course, the change will take effect from the beginning of the following academic year after the changes are introduced and shall cover the part of the course that remains to be completed.

APPENDIX-I
GUIDELINES FOR PREPARATION OF DISSERTATION

Preamble

While utmost attention must be paid to the content of the dissertation report, which is being submitted in partial fulfilment of the requirements of the Dual Degree Masters Programme, it is imperative that a standard format be prescribed. The same format shall also be followed in preparation of the final soft copies to be submitted to the Library in future.

1. Organisation of the Dissertation

The dissertation report shall be presented in a number of chapters, starting with Introduction and ending with Summary and Conclusions. Each of the other chapters will have a precise title reflecting the contents of the chapter. A chapter can be subdivided into sections, subsections and sub-subsection so as to present the content discretely and with due emphasis. When the work comprises two or more mutually independent investigations, the dissertation report may be divided into two or more parts, each with an appropriate title. However, the numbering of chapters will be continuous right through, for example Part 1 may comprise Chapters 2 - 5, Part 2, Chapters 6 - 9.

1.1 Introduction

The title of Chapter 1 shall be Introduction. It shall justify and highlight the problem posed, define the topic and explain the aim and scope of the work presented in the dissertation report. It may also highlight the significant contributions from the investigation.

1.2 Review of Literature

This shall normally form Chapter 2 and shall present a critical appraisal of the previous work published in the literature pertaining to the topic of the investigation. The extent and emphasis of the chapter shall depend on the nature of the investigation.

1.3 Report on the present investigation

The reporting on the investigation shall be presented in one or more chapters with appropriate chapter titles. Due importance shall be given to experimental setups, procedures adopted, techniques developed, methodologies developed and adopted. While important

derivations/formulae should normally be presented in the text of these chapters, extensive and long treatments, copious details and tedious information, detailed results in tabular and graphical forms may be presented in Appendices. Representative data in table and figures may, however, be included in appropriate chapters. Figures and tables should be presented immediately following their first mention in the text. Short tables and figures (say, less than half the writing area of the page) should be presented within the text, while large table and figures may be presented on separate pages. Equations should form separate lines with appropriate paragraph separation above and below the equation line, with equation numbers flushed to the right.

1.4 Results and Discussion

This shall form the penultimate chapter of the dissertation report and shall include a thorough evaluation of the investigation carried out and bring out the contributions from the study. The discussion shall logically lead to inferences and conclusions as well as scope for possible further future work.

1.5 Summary and Conclusions

This will be the final chapter of the dissertation report. A brief report of the work carried out shall form the first part of the Chapter. Conclusions derived from the logical analysis presented in the Results and Discussions Chapter shall be presented and clearly enumerated, each point stated separately. Scope for future work should be stated lucidly in the last part of the chapter.

1.6 Appendix

Detailed information, lengthy derivations, raw experimental observations etc. are to be presented in separate appendices, which shall be numbered in Roman Capitals (e.g. “Appendix IV”). Since reference can be drawn to published/unpublished literature in the appendices these should precede the “Literature Cited” section.

1.7 Literature Cited

This should follow the Appendices, if any, otherwise the Summary and Conclusions chapter. The candidates shall follow the style of citation and style of listing in one of the standard journals in the subject area consistently throughout his/her report. However, the names of all the authors along with their initials and the full title of the article/monogram/book etc. have to be given in addition to the journals/publishers, volume, number, pages(s) and year of publication. Citation from websites should include the names(s) of author(s) (including the initials), full title of the article, website reference and

when last accessed. Reference to personal communications, similarly, shall include the author, title of the communication (if any) and date of receipt.

1.8 Publications by the candidate

Articles, technical notes etc. on the topic of the dissertation report published by the candidate may be separately listed after the literature cited. This may also be included in the contents. The candidates may also include reprints of his/her publications after the literature citation.

1.9 Acknowledgements

The acknowledgments by the candidate shall follow the citation of literature, signed by him/her, with date.

2. DISSERTATION FORMAT

2.1 Paper

2.1.1 Quality: The dissertation report shall be printed / photo copied on white bond paper, whiteness 95% or above, weight 70 gram or more per square meter.

2.1.2 Size: The size of the paper shall be standard A4; height 297 mm, width 210 mm.

2.1.3 Type Setting,Text Processing and Printing: The text shall be printed employing Laserjet or Inkjet printer, the text having been processed using a standard text processor. The standard font shall be Times New Roman of 12 pts with 1.5 line spacing.

2.1.4 Page Format: The Printed Sheets shall have the following written area and margins:

Top Margin 15 mm
Head Height 3 mm
Head Separation 12 mm
Bottom Margin 22 mm
Footer 3 mm
Foot Separation 10 mm
Text Height 245 mm
Text Width 160 mm
When header is not used the top margin shall be 30 mm.

Left and Right Margins

Single sided
Left Margin 30mm
Right Margin 20 mm

2.1.5 Pagination: Page numbering in the text of the report shall be Hindu Arabic numerals at the centre of the footer. But when the candidate opts for header style the page number shall appear at the right and left top corner for the odd and even number pages, respectively. Page number "1" for the first page of the Introduction chapter shall not appear in print, only the second page will bear the number "2". The subsequent chapters shall begin on a fresh page. When header style is chosen the first page of each chapter will not have the header and the page number shall be printed at the centre of the footer. Pagination for pages before the Introduction chapter shall be in lower case Roman numerals, e.g., "iv".

2.1.6 Header: When the header style is chosen, the header can have the Chapter number and Section number (e.g., Chapter 2, Section 3) on even numbered page headers and Chapter title or Section title on the odd numbered page header.

2.1.7 Paragraph format: Vertical space between paragraphs shall be about 2.5 line spacing. The first line of each paragraph should normally be indented by five characters or 12mm. A candidate may, however, choose not to indent if he/she has provided sufficient paragraph separation. A paragraph should normally comprise more than one line. A single line of a paragraph shall not be left at the top or bottom of a page (that is, no windows or orphans should be left). The word at the right end of the first line of a page or paragraph should, as far as possible, not be hyphenated.

2.2 Chapter and Section Format

2.2.1 Chapter: Each chapter shall begin on a fresh page with an additional top margin of about 75mm. Chapter number (in Hindu-Arabic) and title shall be printed at the centre of the line in 6mm font size (18pt) in bold face using both upper and lower case (all capitals or small capitals shall not be used). A vertical gap of about 25mm shall be left between the Chapter number and Chapter title lines and between chapter title line and the first paragraph.

2.2.2 Sections and Subsections: A chapter can be divided into Sections, Subsections and Sub-sub Sections so as to present different concepts separately. Sections and subsections can be numbered using decimal points, e.g. 2.2 for the second section in Chapter 2 and 2.3.4 for the fourth Subsection in third Section of Chapter 2. Chapters, Sections and Subsections shall be included in the contents with page numbers flushed to the right. Further subsections need not be numbered or included in the contents. The Section and Sub-Section titles along with their numbers in 5 and 4mm (16 and 14 pt) fonts, respectively, in bold face shall be flushed to the left (not centred) with 15 mm space above and below these lines. In further subdivisions character size of 3 and 3.5 with bold face, small caps, all caps and italics may be used for the titles flushed left or centred. These shall not feature in the contents.

2.2.3 Table / Figure Format: As far as possible, tables and figures should be presented in portrait style. Small size table and figures (less than half of

writing area of a page) should be incorporated within the text, while larger ones may be presented on separate pages. Table and figures shall be numbered chapter wise.
For example, the fourth figure in chapter 5 will bear the number Figure 5.4 or Fig 5.4 Table number and title will be placed above the table while the figure number and caption will be located below the figure. Reference for Table and Figures reproduced from elsewhere shall be cited in the last and separate line in the table and figure caption, e.g. (after McGregor[12]).

3 Auxiliary Format

3.1 Binding: The evaluation copies of the dissertation report may be spiral bound or soft bound. The final hard bound copies to be submitted after the viva-voce examination will be accepted during the submission of dissertation report with the following colour specification:

Dual Degree Masters Programme Dissertation

3.2 Front Covers: The front covers shall contain the following details:
Full title of report in 6 mm 22 point's size font properly centred and positioned at the top. Full name of the candidate in 4.5 mm 15 point's size font properly centred at the middle of the page. A 40 mm dia replica of the Institute emblem followed by the name of department, name of the Institute and the year of submission, each in a separate line and properly centred and located at the bottom of page.

3.2.1 Lettering: All lettering shall be embossed in gold.

3.2.2 Bound back: The degree, the name of the candidate and the year of submission shall also be embossed on the bound (side) in gold.

3.3 Blank Sheets: In addition to the white sheets (binding requirement) two white sheets shall be put at the beginning and the end of the report.

3.4 Title Sheet: This shall be the first printed page of the Dissertation and shall contain the submission statement: the Dissertation Report submitted in partial fulfilment of the requirements of the M.Tech Degree, the name and Roll No. of the candidate, name(s) of the Supervisor and Co-supervisor(s) (if any), Department, Institute and year of submission.
Sample copy of the 'Title Sheet' is appended (Specimen 'A').

3.5 Dedication Sheet: If the candidate so desires(s), he/she may dedicate his/her report, which statement shall follow the title page. If included, this shall form the page 1 of the auxiliary sheets but shall not have a page number.

3.6 Approval Sheet: In the absence of a dedication sheet this will form the first page and in that case shall not have a page number. Otherwise, this will bear the number two in Roman lower case “ii” at the centre of the footer. The top line shall be: Dissertation Approval for M.Tech
A sample copy of the Approval Sheet is appended (Specimen `B')

3.7 Abstract: The 500 word abstract shall highlight the important features of the dissertation report and shall correspond to the electronic version to be

submitted to the Library for inclusion in the website. The Abstract in the report, however, shall have two more parts, namely, the layout of the report giving a brief chapter wise description of the work and the key words.

3.8 Contents: The contents shall follow the Abstract and shall enlist the titles of the chapters, section and subsection using decimal notation, as in the text, with corresponding page number against them, flushed to the right.

3.8.1 List of Figures and Tables: Two separate lists of Figure captions and Table titles along with their numbers and corresponding page numbers against them shall follow the Contents.

3.9 Abbreviation Notation and Nomenclature: A complete and comprehensive list of all abbreviations, notations and nomenclature including Greek alphabets with subscripts and superscripts shall be provided after the list of tables and figures. As far as possible, generally accepted symbols and notation should be used.

Auxiliary page from dedication (if any) to abbreviations shall be numbered using Roman numerals in lower case, while the text starting from the Introduction shall be in Hindu Arabic.

The first pages in the both the cases shall not bear a page number.

3.10 A Declaration of Academic Honesty and Integrity: A declaration of Academic honesty and integrity is required to be included along with every dissertation report after the approval sheet. The format of this declaration is given in Specimen ‘C' attached.

****

Specimen 'A': Title Sheet

(Title)

Dissertation Submitted in partial fulfilment of the requirements
of the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE)

by

(Name of the Student)
(Roll No._____)

Project Guide(s):

_____

_____

_____
(Name of the Department / School / Division)
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Month and Year)

Specimen `B': Approval Sheet

This dissertation entitled (Title) by (Author Name) is recommended for the award of the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE).

Members of the Examination Committee (Name and Signature)

_____
_____
_____
_____

Date :_____
Place :_____

Specimen `C' – Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

_____
(Signature)

_____
(Name of the student)

_____
(Roll No.)
Date: _____

Specimen `D' – Certificate

DEPARTMENT / SCHOOL OF ----------
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

This is to certify that the dissertation work entitled " ----------" is a bonafide record of work carried out by Mr/Ms ----------(Roll No.), submitted to the Department / School of ----------, in partial fulfilment of the requirements for the award of the offered by Division of Electronics, School of Engineering, CUSAT and Saint Petersburg Electrotechnical University (LETI), Russia during the academic year ----------.

Name and Signature of the Project Guide ----------

Signature of Head of the Division / Department / School ----------

Date:

APPENDIX II

Dual Degree Masters (Full Time) Programme

in

ELECTRONICS ENGINEERING

(NEW GENERATION OF ELECTRONIC COMPONENT BASE)

SCHEME & SYLLABUS

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN– 682 022

DECEMBER – 2023

SCHOOL OF ENGINEERING

Vision

To become, an engineering educational institution of international standing by striving continuously in pursuit of excellence in education, research, entrepreneurship and technology related services to the society.

Mission

1. To provide high quality education in major engineering disciplines from undergraduate through doctoral levels through a creative balance of academic, professional, and extracurricular programmes.
2. To foster and maintain mutually beneficial partnerships with alumni, industry, state and central governments through public services assistance and collaborative research.
3. To be a major contributor to the global technology base through scholarship and research.

Division of Electronics Engineering

Vision

To be a supreme center of quality Electronics Engineering education with a focus on lifelong learning, teamwork and leadership, thus creating a platform for industrial consultancy with global standards through intense research, contributing meaningfully to the development of the country.

Mission

1. Work with a commitment to the highest possible standards of quality in the areas of teaching, research and service
2. Develop a full-fledged centre of learning in various fields of Electronics & Communication Engineering
3. Produce competent engineers adequately prepared to face challenges of the society, adhering to moral and ethical values

Programme Educational Objectives (PEOs)

PEO 1: To prepare graduate students for their professional career as competent Electronics engineers in academics/ research, consultancy, design and innovation.

PEO 2: To prepare graduates to excel in research/entrepreneurship/start-up in the field of Micro and nano electronics, Semiconductor technology and Microwave Integrated circuits in tune with changes in technology leading to a successful career growth.

PEO 3: To enable graduates to acquire professional ethics, effective communication, managerial and team- work skills, to solve humanitarian issues with social and environmental commitment.

PEO 4: To nurture confidence and abilities in graduates through academic environments for promoting lifelong learning in diverse career paths and thus contribute to innovative and sustainable development.

Programme Outcomes (POs)

Electronics Engineering (New Generation of Electronic Component Base) graduates possess the following attributes:

PO1: Have a degree of mastery and in-depth knowledge in Micro and nano electronics, Semiconductor technology and Integrated circuits.

PO2: An ability to independently carry out research /investigation and development work to solve practical problems.

PO3: An ability to write and present a substantial technical report/document.

PO4: Identify, analyze, and solve problems related to Micro and nano electronics, Semiconductor technology and Integrated circuits

PO5: Have theoretical and practical knowhow for topological design of semiconductor devices, elements of integrated circuits, as well as the study and development of basic and advanced technologies for the production of modern integrated circuits.

PO6: Have an ability for lifelong learning with high level of professional and intellectual integrity.

PEO-PO Mapping

PEO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	√	√		√	√	
PEO2	√	√			√	
PEO3			√			√
PEO4		√			√	

Dual Degree Masters (Full Time) Programme in
NEW GENERATION OF ELECTRONIC COMPONENT BASE

SEMESTER I												
Sl No.	Course Code	Course Name	Form of control	Credits CUSAT	Credits ETU	Academic Hours						
						Lec	Lab	P	RC	UW	C	Total
1	24-DEC1-3101	Foreign language / Russian as a foreign language	GT	2	2			34	1	37		72
2	24-DEC1-3102	Computer Technology and Simulation in Electronics	GT	3	3	17	34		3	54		108
3	24-DEC1-3103	Problems of Modern Electronics	GT	2	4	17		17	1	109		144
4	24-DEC1-3104	Basics of Scientific Research	GT	2	2	17		17	1	37		72
5	24-DEC1-3105	Semiconductor Optoelectronic Devices	E	3	5	34		34	1	76	35	108
6	24-DEC1-3106	Integrated and Fiber Optics	E	3	5	34	17	17	1	76	35	180
7	24-DEC1-3107	Academic Internship (Research Project (Acquiring Basic Research Skills))	GT	3	9				1	323		324

TOTAL CREDITS ETU: 30 CUSAT: 18

***Lec-Lecture, Lab- Lab work, P-Practice, RC-Research Coursework, UW-Unsupervised Work, C-Control, GT-Graded Test, E-Exam**

SEMESTER II												
Sl No.	Course Code	Course Name	Form of control	Credits CUSAT	Credits ETU	Academic Hours						
						Lec	Lab	P	RC	UW	C	Total
1	24-DEC1-3201	Foreign language / Russian as a foreign language	GT	2	2			34	1	37		72
2	24-DEC1-3202	Microprocessor Techniques	E	3	3	17	17	17	1	57	35	144
3	24-DEC1-3203	Micro- and nanotechnology processes	E	2	2	17	17	17	1	57	35	144
4	24-DEC1-3204	X-Ray Structural Methods of Material Research	E	3	3		34	17	1	21	35	108
5	24-DEC1-3205	Semiconductor Heterostructure Technology	E	3	3		17	34	1	21	35	108
6	24-DEC1-3206	Computer modeling and design of microwave and optical electronic devices	E	3	3	17	17	51	1	22	35	144
7	24-DEC1-3207X	Elective-I	GT	2	2	17		17	1	37		72
8	24-DEC1-3208	Internship (Research Project)	GT	3	12				2	376		378

TOTAL CREDITS ETU: 30 CUSAT: 21

SEMESTER III												
Sl No.	**Course Code**	**Course Name**	**Form of control**	**Credits CUSAT**	**Credits ETU**	**Academic Hours**						
						Lec	**Lab**	**P**	**RC**	**UW**	**C**	**Total**
1	24-DEC1-3301	Foreign language / Russian as a foreign language	GT	2	2			34	1	37		72
2	24-DEC1-3302x	Elective-II	E	3	4	34	17	17	1	40	35	144
3	24-DEC1-3303x	Elective-III	E	3	4	34		17	1	57	35	108
4	24-DEC1-3304x	Elective-IV	E	3	4	34	17	34	1	23	35	144
5	24-DEC1-3305x	Elective-V	E	3	4	34		34	1	40	35	144
6	24-DEC1-3306	Interdisciplinary project “Designing a Microwave Transistor Power Amplifier”	GT	2	3			8	3	97		108
7	24-DEC1-3307	Research Project PHASE 1	GT	2	9				2	376		378

TOTAL CREDITS ETU: 30 CUSAT: 18

SEMESTER IV												
Sl No.	**Course Code**	**Course Name**	**Form of control**	**Credits CUSAT**	**Credits ETU**	**Academic Hours**						
						Lec	**Lab**	**P**	**RC**	**UW**	**C**	**Total**
1	24-DEC1-3401	Research Project PHASE 2	GT	12	21				2	754		756
2	24-DEC1-3402	Execution and Defense of the Research Project (Graduate Qualifying Work)		3	9				2	322		324

TOTAL CREDITS ETU: 30 CUSAT: 15

Total credits for the M.Tech programme ETU= 120
Total credits for the M.Tech programme CUSAT= 72

***Electives must be selected from the following list for the corresponding semester*

ELECTIVES I (Semester II)	
24-DEC1-32071	Commercialisation of Research and Development Results
24-DEC1-32072	Foreign Economic Activity of Organisations
ELECTIVES II (Semester III)	
24-DEC1-33021	Multijunction Solar Cells Based On III -V Compounds
24-DEC1-33022	Laser Technologies in Manufacturing of Solar modules
ELECTIVES III (Semester III)	
24-DEC1-33031	Laser Physics and Nonlinear Optics
24-DEC1-33032	Basic technologies for the manufacture of integrated circuits
ELECTIVES IV (Semester III)	
24-DEC1-33041	Laser Fundamentals
24-DEC1-33042	Electronics and Radiophotonics Materials Diagnostics
ELECTIVES V (Semester III)	
24-DEC1-33051	Carbon Nanoelectronics
24-DEC1-33052	Photonics Materials

M. Tech Degree (Full Time) Programme in

NEW GENERATION OF ELECTRONIC COMPONENT BASE

SEMESTER – I

24-DEC1-3101 FOREIGN LANGUAGE / RUSSIAN AS A FOREIGN LANGUAGE

Course Objectives: ***On completion of this course the student will be able to:***

1. Obtain knowledge of a foreign language (English, German, and French) for communication in professional and socio-social spheres of activity.
2. Form skills of translation and interpretation of original texts on specialty, using the skills of translation transformations, using the knowledge of general scientific and terminological vocabulary.
3. Form the knowledge of lexical, grammatical and stylistic norms of the modern language, the main features of scientific style of speech, as well as the rules of construction and transformation of a scientific text and the ability to implement them to carry out communication and work with specialised literature.
4. Apply in practice the knowledge of the norms of modern language and the main features of scientific style of speech; to read and understand without a dictionary special and general scientific texts; to have a free conversation and participate in a discussion on the topics of training and on a free topic.
5. Write structured texts; to use communicative technologies of speech construction.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			3
CO2			3			3
CO3			3			3
CO4			3			3
CO5			3			3

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
1	Introduction.	Teaching speech activity on the material of original texts, improving the necessary speech skills and specific skills in reading, speaking, listening, writing and translation. Reading literature.
2	Topic 1. Education, academic institutions	Education/Ausbildung/L'éducation. Grammatical topics: Passive voice, modal verbs, infinitives. Study of general scientific vocabulary in the following sections Academic institutions/Lehranstalten/Les établissements d'éducation académique, academic vocabulary/Lehran/Le dictionnaire académique
3	Topic 2. Science world	The world of science/ Welt der Wissenschaft/ Le monde de la science/: science, technology, famous scientists, professional achievements. Grammatical topics: gerunds, participles, participial turns. Writing annotations and abstracts for texts on the speciality. General scientific vocabulary

4	Topic 3. Academic speaking and writing for academic purposes	Speaking and writing for academic purposes/ Sprechen und Schreiben für Akademische Zwecke/a production orale et la production écrire pour les fins académiques. Presentation on scholarly achievements; interview, perspectives, summary. General scientific vocabulary. Business Communication: key expressions.
5	Conclusion.	Translation of the text, interview. The knowledge acquired during the course is necessary for further education at postgraduate level, in professional activities and for self-education.

List of practical classes

Name of the practical classes	Number of ac. hours.
1. Grammar. Russian /German/French language.	33
2. Writing. Russian /German/French language.	8
3. Listening/speaking. Russian /German/French language.	45
4. Reading. Russian /German/French language.	8
5. Translation. Russian/German/French language.	8
Total	102

Individual homework

1. Reading and translation of an original text (in Russian/ German/French) from a scientific journal. Volume 30 thousand characters.
2. Making a glossary of terms and general scientific vocabulary to the original text. The volume of 100 lexical units.

The student's progress evaluation includes:

1. Verbal presentation of the content of the original text presented by the student.
2. Interpretation of an excerpt from the presented text (1200 1300 print units).
3. Glossary, knowledge of Russian/English TERMS

24-DEC1-3102 COMPUTER TECHNOLOGY AND SIMULATION IN ELECTRONICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Model electronic systems using modern computer technologies.
2. To study methods of analytical solution of systems of differential equations describing the operation of micro and nanoelectronics devices and model them using MathCAD, LabView, MatLab and Sinopsys.
3. To acquire the skills to choose a method and software environment for modeling devices of micro and nanoelectronics.
4. Apply computer technology in science and production.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3		3	3	3
CO2		3		3	3	2
CO3	3	2	2	3	3	2
CO4	3			3	3	2

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	The subject of the course and its purpose. Relation of the course with other disciplines of the curriculum. Review of basic software packages used for computer modelling of electronic components and devices. Physicotopological models of semiconductor devices. The problems of numerical modelling of semiconductor devices and technological processes are considered. Basic equations of semiconductor structures physics are given.
2	Numerical methods	This topic is devoted to numerical methods used in modelling semiconductor devices and technological processes: the concept of numerical derivative is introduced and numerical methods for solving transcendental equations, such as the bisection method and the Newton-Raphson method, are considered; numerical methods for solving differential equations, the Cauchy problem and boundary conditions are formulated, conditions for applying the Euler method, as well as explicit and implicit Runge-Kutta methods are considered..
3	Field penetration of a semiconductor	In this topic, the principles of operation of a left-handed Schottky transistor are considered, and a one-dimensional problem of field penetration into a semiconductor is solved in order to determine the position of the effective boundary of the charge carrier-depleted zone, as well as the conditions of channel closure. Approximations of sharp and blurred boundary are considered. The questions of taking into account diffusion and drift of charge carriers in the channel, boundary layer effects, and processes occurring in the "current channel-buffer layer" region are considered.

4	Modelling of solid state electronics devices	This topic is devoted to modelling of MESFET and MOSFET transistors characteristics: methods and approaches of numerical modelling of processes occurring in the active region of transistors are considered, physical models of electronics devices are formulated, diffusion-drift and hydrodynamic models of calculation are considered. The basics of device-technological modelling in Synopsys software environment are also studied in the course, using MESFET and MOSFET transistor modelling as examples.
5	Instrumentation and process modelling	This topic is devoted to solving technological problems of semiconductor devices creation. Analytical solutions of diffusion problems are given, and the processes of oxidation and doping of semiconductor crystals to create transistor structures are considered. The methods of modelling technological processes in the Synopsys software environment are studied.
6	Conclusion	This topic discusses the prospects for the development of computer modelling systems for the design of micro and nanoelectronics components.

List of laboratory works

Name	Ac/h
1. Field penetration into a semiconductor in the sharp boundary approximation: "depleted region-channel" of a Schottky field-effect transistor.	3
2. Field penetration into a semiconductor in the gap boundary approximation: the "depleted region-channel" of a Schottky field-effect transistor.	3
3. Field penetration into a semiconductor. Determination of the position of the effective boundary: "depleted region-channel" of a Schottky field-effect transistor.	3
4. Modelling of solid state electronics devices in Synopsys Sentaurus TCAD environment. MESFET transistor in diffusion-drift model.	6
5. Modelling of solid state electronics devices in Synopsys Sentaurus TCAD environment. MOSFET transistor in diffusion-drift model.	6
6. Modelling of solid state electronics devices in Synopsys Sentaurus TCAD. MOSFET transistor with a short channel in a hydrodynamic model.	6
7. Modelling of technological processes in Synopsys software environment. Processes of oxidation and doping of semiconductor crystals to create transistor structures.	7
Total	34

Reference Books:

1. “Technology Computer Aided Design, Simulation for VLSI MOSFET”, Chandan Kumar Sarkar, CRC Press, Taylor & Francis, 2018.
2. “Concepts, Strategies and Models to Enhance Physics Teaching and Learning”,Eilish McLoughlin, Paul van Kampen, Springer International Publishing, 2019.
3. “High-Speed Circuit Board Signal Integrity, Second Edition”, Stephen C.Thierau,Artech House,2017
4. “3D TCAD Simulation for CMOS Nanoelectronic Devices”,Yung-Chun Wu, Yi-Ruei Jhan ,Springer Nature Singapore,2017

24-DEC1-3103 PROBLEMS OF MODERN ELECTRONICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Understand the main trends and prospects in the development of modern electronics and nanoelectronics, advanced domestic and foreign scientific experience in the professional field.
2. Acquire skills in the field of preparation of literature reviews and patent reviews.
3. Evaluate the correct choice and use of modern design methods and manufacturing technologies for electronics and nanoelectronics devices.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2		2	3	
CO2			3			3
CO3	3	3		3	3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	The discipline introduces current problems and the latest developments in solid-state electronics, lays down the necessary skills to solve problems in the field of creating new nanoelectronic devices, and provides conditions for the successful completion of the final qualification work.
2	Technology of amorphous semiconductors and their application	The structure of amorphous semiconductors. Model of energy zones. Mechanisms of charge transfer in amorphous semiconductors. Tetrahedral amorphous semiconductors. Chalcogenide semiconductors. Development of thin-film technologies. Microelectronics.
3	Scanning probe microscopy in nanotechnology	Fundamentals of scanning probe microscopy (SPM) methods. Scanning tunneling microscopy (STM). Atomic force microscopy (AFM). Surface scanning modes. Nanotechnological applications of SPM methods.
4	Solid-phase silicon splicing, Smart Cut technology	SDI technology (silicon with dielectric insulation). Technology and mechanism of solid-phase direct splicing (SDS). Surface energy. Defects and quality control of surfaces. The use of SDS in electronics. SmartCut process.
5	Ionizing radiation detectors in science and technology	Mechanisms of radiation absorption by the recording medium. Gas proportional detectors. Principles of operation of a semiconductor detector Detectors with PN junction. Detectors with MSM structure. Signal generation in the detector. Loss of charge. Noise of semiconductor detectors.
6	Thermoelectric energy converters today and tomorrow	Physical principles of operation of thermoelectric energy converters. Thermoelectric generators. Thermoelectric coolers. Thermoelectrics. Thermoelectric efficiency.

7	Physical fundamentals of microelectronics	The phenomenon of superconductivity. Superconductors 1 and 2 genera. High-temperature superconductivity. Superconducting devices: cryotrons, cryo-electronic amplifiers and resonators, superconducting quantum interference devices (SQUID) digital devices.
8	Porous silicon and its application in silicon microphotonics	Silicon microphotonics. Preparation and properties of porous silicon. The mechanism of vaporization. Microporous, mesoporous and macroporous silicon. Areas of application. Photonic crystals.
9	Ultra-wideband radio electronics	A brief description of ultra-wideband (UWB) devices. Definition of UWB devices. Existing UWB standards. Problems of compatibility of USB devices with narrowband communication systems. Principles of formation of short pulses. Drift diodes, transistors and thyristors with sharp recovery. Diode avalanche exacerbators. Generators of short pulses.
10	Magnetic and ferroelectric memory	The main trends in the development of non-volatile storage devices in the microelectronic industry. Factors of increasing storage capacity and modern developments in the field of non-volatile memory. Magnetic memory. Evolution of non-volatile programmable magnetic memory from devices based on cylindrical magnetic domains and Abrikosov vortices to devices using a giant magnetoresistive effect. Ferroelectric memory: random-access storage devices and non-volatile ferroelectric storage devices. Transistor ferroelectric structures. Ferroelectric structures with optical reading and optical recording of information.
11	Conclusion	Prospects for the development of modern electronics and nanoelectronics

List of practical classes

Name	Ac/h
1. The structure of amorphous semiconductors. Model of energy zones. Mechanisms of charge transfer in amorphous semiconductors.	1
2. Tetrahedral amorphous semiconductors. Chalcogenide semiconductors. Development of thin-film technologies. Microelectronics.	1
3. Fundamentals of STM methods. Scanning tunneling and atomic force microscopy.	1
4. Surface scanning modes. Nanotechnological applications of STM methods.	1
5. SDI and SDS technologies. Surface energy. Defects and quality control of surfaces.	1
6. Application of SDS in electronics. SmartCut process.	1

7. Mechanisms of radiation absorption by the recording medium. Principles of operation of a semiconductor detector	1
8. Detectors with r-p transition and MSM structure. Signal generation. Noise of semiconductor detectors.	1
9. Physical principles of operation of thermoelectric energy converters. Thermoelectric generators. Thermoelectric coolers.	1
10. Thermoelectrics. Thermoelectric efficiency.	1
11. The phenomenon of superconductivity. Superconductors of the 1st and 2nd kind. High-temperature superconductivity.	1
12. Devices based on superconductors: cryotrons, cryo-electronic amplifiers and resonators, SQUID, digital devices.	1
13. Silicon microphotonics. Preparation and properties of porous silicon. The mechanism of vaporization. Microporous, mesoporous and macroporous silicon. Areas of application. Photonic crystals.	1
14. Semiconductor short pulse shapers a drift diode with a sharp recovery and an avalanche diode sharpener.	1
15. Short pulse generator based on a drift diode with sharp recovery.	1
16. The main trends in the development of non-volatile storage devices. Magnetic memory.	1
17. Non-volatile ferroelectric storage devices with electrical and optical recording and reading of information.	1
Total	17

Report

The purpose of the task: to conduct students' independent search and analysis of information on a given topic, to deepen the knowledge gained at lectures, to master the skills of expanding their professional horizons and presenting information and participating in discussions. Students receive a choice of topics for oral presentations with a presentation. List of topics:

1. The structure of amorphous semiconductors.
2. Model of energy bands. Charge transfer mechanisms in amorphous semiconductors.
3. Tetrahydric amorphous semiconductors.
4. Chalcogenic semiconductors.
5. Development of thin-film technologies.
6. Macroelectronics.
7. Fundamentals of scanning probe microscopy (SPM) methods.
8. Scanning tunneling microscopy (STM).
9. Atomic force microscopy (AFM).
10. Surface scanning modes.
11. Nanotechnological applications of SPM methods.
12. Technology SOI (silicon on insulator).
13. Technology and mechanism of solid-phase direct splicing (TPS).
14. Surface energy.
15. Defects and surface quality control.
16. Application of TPS in electronics. smart cut process.
17. Mechanisms of radiation absorption by the recording medium.
18. Gas proportional detectors.
19. Principles of Operation of a Semiconductor Detector
20. Detectors with a p-n junction.
21. Detectors with MMM structures.

22. Formation of a signal in the detector.
23. Loss of charge in the detector.
24. Noise of semiconductor detectors.
25. Physical principles of operation of thermoelectric energy converters.
26. Thermoelectric generators.
27. Thermoelectric coolers.
28. Thermoelectrics.
29. Thermoelectric efficiency.
30. The phenomenon of superconductivity.
31. Superconductors of the 1st and 2nd kind.
32. High temperature superconductivity.
33. Devices based on superconductors: cryotrons, cryoelectronic amplifiers and resonators, superconducting quantum interference devices (SQUID) digital devices.
34. Silicon microphotonics.
35. Obtaining and properties of porous silicon.
36. Pore formation mechanism.
37. Microporous, mesoporous and macroporous silicon. Areas of use.
38. Photonic crystals.
39. Brief description of ultra-wideband (UWB) devices.
40. Definition of UWB devices.
41. Existing UWB standards.
42. Problems of compatibility of UWB devices with narrowband communication systems.
43. Principles of formation of short impulses.
44. Drift diodes, transistors and thyristors with fast recovery.
45. Diode avalanche sharpeners.
46. Short pulse generators
47. The main trends in the development of non-volatile storage devices in the microelectronic industry.
48. Factors of increasing the capacity of storage devices and modern developments in the field of non-volatile memory.
49. Magnetic memory.
50. Evolution of non-volatile reprogrammable magnetic memory from devices based on cylindrical magnetic domains and Abrikosov vortices to devices using the giant magnetoresistive effect.
51. Ferroelectric memory: Random access memories and non-volatile ferroelectric memories.
52. Transistor ferroelectric structures.
53. Ferroelectric structures with optical reading and optical recording of information.

Reference Books:

1. "Amorphous Semiconductors Structural, Optical, and Electronic Properties", Kazuo Morigaki, Sandor Kugler, Koichi Shimakawa, Wiley,2016
2. "Ferroelectric Materials and Applications",Kamal Asadi, Elsevier Science, 2021
3. "Multifunctional Ultrawideband Antennas Trends, Techniques and Applications",Chinmoy Saha, Jawad Y Siddiqui, Y M M Antar ,CRC Press, 2019
4. "Porous Silicon: From Formation to Applications: Optoelectronics, Microelectronics, and Energy Technology Applications", Ghenadii Korotcenkov, CRC Press, 2016

24-DEC1-3104 BASICS OF SCIENTIFIC RESEARCH

Course Objectives: ***On completion of this course the student will be able to:***

1. Work with general scientific and special categorical system, preparation various types of scientific publications.
2. Acquire knowledge of how to analyse and take into account the diversity of cultures in the process of intercultural interaction.
3. Form the knowledge of the methods of scientific research and the scientific ethics basics.
4. Form abilities to conduct scientific research; navigate and analyze data, compile scientific documentation; prepare manuscripts and grant projects.
5. Master the basic methods of modern science, the main forms of scientific knowledge (scientific law, principle, hypothesis and theories), as well as the ability of mastering the procedures to explain and justify.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3			2
CO2		2				3
CO3		3				3
CO4		3				2
CO5		3				3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	The importance of history and philosophy for the formation of a scientific worldview, the identification of trends and prospects for the development of modern science. Historical and logical aspect in the development of science.
2	Modern science and its structure	1. The concept, structure and functions of modern science. 2. Foundations of scientific research. Scientific rationality and its types (classical, non-classical and post-non-classical). 3. The main types of scientific research and criteria of analysis: fundamental, applied, subject, interdisciplinary, etc. 4. The levels of reflection in scientific research: philosophical, scientifically oriented, interdisciplinary, particularly scientific, etc.
3	Traditions, innovations and new developments in scientific research activities	1. Scientific pictures of the world (general scientific, natural-science, socio-humanitarian, technical) and their change. 2. Types and kinds of scientific revolutions. The essence and peculiarities of scientific and technological revolution. 3. The concept of innovation, innovative technology, strategy and activity. The levels and typology of innovations. The concept of civilizational and technological limits.

4	Methodology of scientific research	1. The concept and structure of the methodology of science. 2. Methods of empirical research (observation, experiment, measurement, modeling). 3. Philosophical and general scientific methods and approaches that used in scientific-theoretical research. 4. Methods of scientific theoretical research (methods of idealization, formalization, axiomatization, hypothetical-deductive, mental experiments and mathematical modeling).
5	Methodology of Linguistics	1. Objectives and principles of linguistic research structuring. 2. Problems of linguistic methodology. 3. Methods of linguistic research.
6	The logic of scientific research	1. Scientific and situation problems, the requirements for the statement of scientific problems. 2. Correlation of scientific principles and laws. 3. Scientific fact: the concept, types and functions in scientific research. 4. Scientific hypothesis and scientific idea: logical and substantive requirements to statement of hypotheses. Classification of hypotheses. 5. The concept of scientific theory and its role in scientific cognition, structure, types and functions of scientific theories. 6. Logical structure of explanation and conditions of its adequacy. A variety of types of scientific explanations. 7. The problem of truth in science. Concepts of truth. Correlation of science and truthfulness of knowledge.
7	Argumentation and justification in scientific research	1. Argumentation as a logical procedure. 2. Structure and types of argumentation. The role of argumentation in scientific reasoning. 3. The essence of evidence and its types. 4. Contradiction and its types. 5. Specificity of confirmation and criticism as types of argumentation. 6. Rules of justification and possible errors.
8	The culture of preparing scientific publications	1. The concept of scientific publication 2. Structure and types of scientific publications 3. Preparation and design of scientific publications
9	Conclusion	The problem of truth in science. Concepts of truth. Correlation of science and truthfulness of knowledge. Methodology formation of innovative researches and types innovative scientific activity.

List of practical classes

Name	Ac/h
1. Modern science and its structure	2
2. Traditions, innovations and new developments in scientific research activities	2
3. Methodology of scientific research	2
4. Methodology of Linguistics	2
5. The logic of scientific research	2
6. Argumentation and justification in scientific research	3
7. The culture of preparing scientific publications	4
Total	17

Reference Books:

1. "Modelling-based Teaching in Science Education", John K. Gilbert, Rosária Justi, Springer International Publishing, 2016
2. "Research Methods in Linguistics Second Edition", Lia Litosseliti, Bloomsbury Publishing,2018
3. "Handbook for the Historiography of Science" Marlon Salomon, Mauro L. Condé, Springer International Publishing,2023
4. "Methodological Prospects for Scientific Research From Pragmatism to Pluralism",Wenceslao J. Gonzalez, Springer International Publishing,2020

24-DEC1-3105 SEMICONDUCTOR OPTOELECTRONIC DEVICES

Course Objectives: ***On completion of this course the student will be able to:***

1) Know the main types of devices and devices of semiconductor optoelectronics defined in the programme.
2) Apply the acquired knowledge to explain the principles of operation of devices and devices of semiconductor optoelectronics, as well as optical methods of information transmission and processing.
3) Possess the basic methods of construction of optoelectronic systems and devices of semiconductor optical electronics.
4) Acquire knowledge of optical properties of semiconductors and semiconductor heterostructures, principles of operation and designs of semiconductor lasers, light-emitting diodes, photodetectors and photoconverters, areas of application of semiconductor optoelectronic devices.
5) Design devices, appliances and systems of electronic technology taking into account the given requirements.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3				3	1
CO2	3			2	3	2
CO3	3			3	3	2
CO4	3			3	3	3
CO5	3	2		2	3	2

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
1	Introduction	The subject of the discipline and its objectives. Features of semiconductor optoelectronics. Standard terminology, basic concepts and definitions. Brief historical sketch. Classification of semiconductor optical electronics devices. Their role in modern science and technology. Connection with other disciplines.
2	Optical properties of semiconductors and semiconductor heterostructures	Electronic states in semiconductors and semiconductor solid solutions. Types of optical transitions in semiconductors. Optical absorption. Recombination emission in semiconductors. Quantum yield of luminescence. Influence of temperature and doping level on electroluminescence. Features of population inversion in semiconductors. Heterojunctions in semiconductors. Properties of heterojunctions. Effects of one-sided injection and superinjection. Wide-area window effect. Waveguide effect. Photoelectric effects in heterojunctions and varison structures. Quantum-dimensional effects, quantum wells, filaments and dots.

3	LEDs	The principle of operation and features of LEDs. Efficiency LEDs. Ways to improve the parameter optical output of radiation. Emission spectrum and brightness. Design and basic parameters LEDs. Directional diagram. LEDs for fibre optic communication lines. White LEDs.
4	Semiconductor lasers	Types of semiconductor lasers. Lasers on double heterostructures. Basic characteristics of semiconductor injection lasers. Spatial and spectral characteristics. Calculation of threshold current density and output power. Radiation output and radiation pattern. Reliability of injection lasers. Strip heterolasers. Lasers with separate optical and electronic confinement. Lasers using quantum-dimensional effects. Heterolasers with distributed feedback. Tunable semiconductor IR lasers. High-power injection lasers, laser lines and gratings. Surface-emitting microlasers. Cascade lasers.
5	Photoresistors	Classification and technical characteristics of receivers optical radiation. Semiconductor photodetectors. Photoresistors. Parameters of photoresistors. Spectral, light and voltampere characteristics of photoresistors. Inertia of photoresistors. Noise and equivalent circuit of photoresistor.
6	Photodiodes	Photodiodes based on pn-junctions. Modes of photodiode operation. Voltampere, spectral, light and frequency characteristics of photodiodes based on pn-junctions. Pin-photodiodes and their main characteristics. Photodiodes with Schottky barrier. Heterophotodiodes. Avalanche photodiodes. Avalanche multiplication and impact ionisation coefficients. Design of avalanche photodiodes and their main characteristics. Avalanche photodiodes based on superlattices. Frequency characteristics and noise of avalanche photodiodes.
7	Solar photovoltaic converters, phototransistors and CCD	Solar irradiation and ideal conversion efficiency solar cells based on pn-junctions. Solar cells based on heterojunctions. Surface and thin film solar cells. Bipolar phototransistor. Voltampere, light and frequency characteristics of bipolar phototransistor. Phototransistors with heterojunctions. MDS phototransistors. Photothyristors - principle of operation and basic characteristics. CCD photodetectors and their characteristics.
8	Semiconductor optoelectronic applications	The application of semiconductor lasers for storing and recording of information on compact discs. Types compact discs. Single and multiple rewritable discs. Magneto-optical discs. Fibre optic communication lines. Laser printers. Optical scanners. Integrated optical circuits.
9	Conclusion	Main trends and directions of development of quantum electronics and optoelectronics

List of practical classes

Sl. No.	Name of the topic of the discipline	Academic hours
1	Optical properties of semiconductors and semiconductor heterostructures	6
2	LEDs	5
3	Semiconductor lasers	5
4	Photoresistors	4
5	Photodiodes	4
6	Solar photovoltaic converters, phototransistors and CCD	5
7	Semiconductor optoelectronic applications	5
	Total	34

Reference Books:

1. "Semiconductor Materials", Lev I. Berger ,CRC Press, 2020
2. "Quantum Dot Lasers on Silicon Nonlinear Properties, Dynamics, and Applications", Bozhang Dong,Springer International Publishing, 2023
3. "Computational Electronics ",Dragica Vasileska, Stephen M. Goodnick, Springer International Publishing ,2022
4. "Handbook of Optoelectronics Applied Optical Electronics (Volume Three) · Volume 3", John P. Dakin, Robert G. W. Brown, CRC Press, 2017

24-DEC1-3106 INTEGRATED AND FIBER OPTICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Study the basics of theory and methods of calculation of optical planar waveguides used in integrated optics.
2. Acquire skills of application of calculation methods for optical waveguides with circular symmetry used in optical communication lines.
3. Understand about physical processes of electromagnetic waves propagation in optical waveguides of different types and methods of manufacturing of optical waveguides.
4. Acquire skills of collecting information on the application of optical waveguides and fibers in various fields of science, technology and medicine.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			3	3	1
CO2	3	1		3	3	2
CO3	3	2		3	3	1
CO4	3			3	3	2

1- slightly, 2- moderately, 3-substantially

Contents

№	Name	Content
1	Introduction	Aims and objectives of the course. Course structure. Subject of study, basic definitions and concepts.
2	Section 1. Theory of optical waveguides. Topic 1. Classification of waveguides, applications of different types of waveguides	Planar, strip waveguides, circular waveguides, gradient waveguides, Bragg waveguides, amplified waveguides, photonic crystal and plasmonic waveguides. Fabrication methods and applications.
3	Topic 2. Radial description of planar three-layer dielectric waveguides.	Conditions for waveguide modes, phase synchronism condition, characteristic equation, types of waveguide modes.
4	Topic 3. Electrodynamic description of planar three-layer dielectric waveguides	Wave equations, solution of wave equations, waveguide mode field amplitude distribution.
5	Topic 4. Planar waveguides with parabolic refractive index distribution.	Features of waveguides with parabolic refractive index profile, beam trajectory in such waveguides, mode dispersion, application of waveguides with parabolic refractive index profile.
6	Topic 5. Electrodynamic description of a circular waveguide (fibre).	Wave equations in cylindrical coordinates, solution of wave equations, distribution of waveguide mode field amplitudes in circular section waveguides.

7	Topic 6. Metal-coated waveguides. Hollow waveguides.	Excitation of surface electromagnetic waves, field distribution for different types of modes. Application of metal-coated waveguides.
8	Topic 7. Corrugated and periodic waves of water.	Solution of coupled mode equations, resonance properties of corrugated and periodic waveguides.
9	Topic 8. Photonic crystal and plasmonic waveguides.	Peculiarities of electromagnetic wave propagation in photon-crystalline and plasmonic waveguides. Varieties of such waveguides. Advantages and fields of application of waveguides of this type.
10	Topic 9. Coupled waveguides.	Solution of the coupled mode equations. Conditions of waveguide modes flowing from one waveguide to another. Applications of coupled waveguides.
11	Topic 10. Waveguide lasers and amplifiers.	Peculiarities of waveguide modes formation in amplified media. Coordination of waveguide and resonator modes. Applications of waveguide lasers and amplifiers. Fibre lasers and amplifiers, waveguide CO2 laser.
12	Section 2. Functional nodes and elements in locular and integral optics. Topic 11. Passive functional nodes and elements of fibre and integrated optics.	Radiation input and output devices, couplers, multiplexers, Mach–Zehnder interferometer, insulators, fibre connectors.
13	Topic 12. Waveguide filters and resonators.	Filters on Bragg waveguides, ring resonators, photonic crystal resonators.
14	Topic 13. Active functional nodes and elements of fibre and integrated optics.	Optical switches based on electro-optical and non-linear optical effects, optical signal switches, integrated micromechanical switches.
15	Topic 14. Plasmonic devices for integrated optics.	Optical properties of metals. The concepts of plasmon and surface electromagnetic wave. Types of plasmons. Methods of mathematical description of plasmonic waveguide modes. Examples of plasmonic devices of integrated optics and their advantages.
16	Topic 15. Integral optical devices for optical communication and information processing.	Integral optical switches and commutators, logic devices. Advantages of integrated optical devices.

17	Topic 16. Fibre optic sensors and meters of physical quantities. Fibre optics and integral optics in medicine.	Advantages of fibre optic sensors. Effects used in sensors for measuring physical quantities. Examples of fibre sensors for temperature, pressure, magnetic field, electric current, refractive index of medium. Fields of application of fibre sensors. Application of optical fibres for investigation of internal organs and therapeutic and surgical effects on them. Optical waveguides and elements of integrated optics in microfluidics, including protein detection.
18	Section 3. Fibre optic communication lines. Topic 17. Dispersion and losses in optical fibre. Topic 18. Wavelength division multiplexing (WDM) based fibre links. Conclusion.	Advantages of optical methods of information transmission. Structure of a fibre communication line. Multiplexers, demultiplexers, fibre amplifiers and generators. Causes of attenuation of optical signals in fibres. Losses and distortions of signals related to chromatic and mode dispersion. Influence of nonlinear optical effects on distortion of optical signals in fibre links.

List of laboratory works

Name	Ac/h
1. Study of the modes of optical waveguides	3
2. Measurement of the efficiency of radiation input into the optical window through the end face	4
3. Measurement of radiation divergence from the output of optical waveguides and phased waveguide arrays	4
4. Measurement of light scattering losses in a rectangular optical waveguide	3
5. Measurement of optical signal distribution uniformity with a Y splitter	3
Total	17

List of practical classes

Name	Ac/h
1. Calculation of reflection coefficients and phase shift at the interface between two media	2
2. Constructing the guided mode field distribution for a three-layer planar waveguide	4
3. Calculation of coupled waveguides	2
4. Calculation of optical properties of composites	2
5. Energy calculation of a fibre optic communication line	2
6. Preparation for course work	1
7. Tests on individual calculation tasks	4

Total	17

Reference Books:

1. “Computational Photonic Sensors”, Mohamed Farhat O. Hameed, Salah Obbaya, Springer International Publishing, 2018.
2. “Applications of Semiconductor Optical Amplifiers”,Kyriakos E. Zoiros,Mdpi,AG,2018
3. “Fundamentals of Fiber Lasers and Fiber Amplifiers”, Vartan V. Ter-Mikirtychev, Springer International Publishing,2019
4. “Encyclopaedia of Medical Physics Two Volume Set”, Franco Milano, Magdalena S. Stoeva, Perry Sprawls, Sameer Tipnis, Slavik Tabakov, Tracy Underwood, CRC Press,2021

24-DEC1-3107 ACADEMIC INTERNSHIP (RESEARCH PROJECT

(ACQUIRING BASIC RESEARCH SKILLS))

Master's 1st year Internship provides production and consolidation of professional knowledge and skills acquired by them during the period of study at undergraduate and 1st year master degree in the field of conducting independent research.

Aims and objectives of the discipline

1. Educational internship of Master students is aimed at strengthening the professional knowledge, skills acquired by them in the process of training, as well as obtaining primary practical skills in conducting independent research work.

2. the main task of the master student during the training internship is to strengthen the professional knowledge, skills and abilities received by them during the period of study in the bachelor's degree and the 1st year of study in the master's degree in the field of conducting independent research activities.

3. As a result of the internship the student acquires initial scientific and technical knowledge on the given subject in Russian/English and foreign language sources, develops his/her own opinion about the content of the received information.

4. Formation of the ability to discuss and defend their opinion (in conversation with the head of internship or with students of the group) about the innovation, scientific, technical or practical significance, about possible applications of the obtained information.

5. Mastering the methods and areas of searching for necessary information in various sources: educational, reference literature, monographs, periodical scientific and technical publications (journals, reviews, proceedings, etc.), bibliographic publications, reference books, catalogues, electronic resources, as well as acquiring the skills of systematisation and accumulation and storage of collected information.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3				3
CO2		3				3
CO3		3				3
CO4		3				3
CO5		3				3

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Sections (stages) of practice	Types of work, including independent student work	Forms of current examination
1	Preparatory	1. Development of individual assignment. 2 Meeting to explain the aims, objectives, content and procedure of the internship. 3. Introducing the place of practice	Supervising organisational issues, goals, objectives and content tasks

2	Main	1. Collection and processing of regulatory and legal, production and technological information. 2. Fulfilment of individual assignments.	Results
3	Final	1. Writing and drawing up a report on practice. 2. Defence of the report (interim assessment)	Feedback from the supervisor of internship from the enterprise (organisation). Verification of the internship report

INTERNSHIP SUPERVISOR

Internship supervision is carried out by the internship supervisor from CUSAT and by the internship supervisor from the organisation (enterprise), if the internship is carried out in the organisation (enterprise).

The supervisor of the organisation develops individual tasks, content and planned results of internship, provides workplaces, provides safe conditions of internship for students, meeting sanitary rules and requirements of labour protection, provides instruction of students on familiarisation with requirements of labour protection, safety, fire safety, as well as rules of internal order. After the internship the supervisor evaluates the work of the student and gives feedback. The feedback evaluates the attitude to work, completeness of the completed task.

The head of internship from the university agrees individual tasks for students, performed during the internship at the enterprise and develops individual tasks performed during the internship in CUSAT. Controls the observance of the terms of internship and compliance of its content with the established requirements, provides methodological assistance to students in the performance of individual tasks, collection of materials for the report and materials that can be used for research work and writing a graduate qualification work, evaluates the results of internship students.

EXAMPLE OF INDIVIDUAL WORKS

1. Electrophysical properties of ferroelectric capacitors based on thin-film solid solutions of barium titanatezirconate
2. Modeling the Thermal Modes of a MOSFET Transistor
3. Simulation of the bistable transfer characteristics of a silicon ring resonator
4. Study of the training possibility of chaotic systems
5. Mathematical modeling of the processes of pumping gas from a vacuum system
6. Ferroelectric films for use in electrocaloric devices
7. Investigation of broadband radiophotonic phase shifters

FORM OF FINAL INTERNSHIP REPORTING

The document on the results of the internship of the student is a report. In it, the student gives a brief characteristic of the place of internship, tasks and operations that he performed during the internship. Terms of submission and defense of reports on internship are established in accordance with the calendar schedule of the educational process.

The report shall be technically competent, may be illustrated with sketches, diagrams, tables, photographs. The report together with the collected materials can be used in the future when writing the final qualification work.

Internship report can also be defended at the place of work. In this case, the student submits a report to the department with an assessment, signed by the supervisor of internship from the enterprise, the assessment is taken into account when defending the report at the university, the final grade is entered in the statement and the credit book by the head of internship from the university.

SEMESTER – II

24-DEC1-3201 FOREIGN LANGUAGE / RUSSIAN AS A FOREIGN LANGUAGE

Course Objectives: ***On completion of this course the student will be able to:***

1. Gain knowledge of phonetic, lexical and grammatical and norms of the modern Russian language.
2. Develop the skills of making statements based on the intentions arising in simple situations of a standard type.
3. Achieve linguistic, social-cultural and communicative skills and abilities that enable foreign students to solve communicative tasks in academic, every day and cultural spheres of communication.
4. Obtain knowledge of grammar, morphology and syntax of the Russian language to the extent of the curriculum of the elementary certification level.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			3
CO2			3			3
CO3			3			3
CO4			3			3
CO5			3			3

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
9	Topic 1. The concept of verb types. (Semester 2).	1. Verb. Infinitive. Imperfective and perfective verb types. Basic meanings of verb types. Formation of Imperfective and perfective verb types. Present, past and future tense of the verb. Verb base, 1st and 2nd Conjugation of the verb. Classes and groups of verbs. Imperative from known verbs. Verb control (смотрю телевизор). Transitive and non-transitive verbs (встретил брата). 2. Numerals. 3. Topics of texts for reading, conversations, listening: Разговор по телефону.
10	Topic 2. Dative case of nouns.	1. Dative case of кому? чему? Direct and indirect speech (глаголы спросить, сказать, ответить). Grammatical construction Кому? сколько? лет. Grammatical construction Кому? нужно… (Кому? нужно + инфинитив). 2. The construction "Сколько стоит ...?". 3. Topics texts for reading, talking, listening: В магазине.
11	Topic 3. Prepositionless verbs of motion.	1. Verbs of motion without prefixes - ИДТИ, ХОДИТЬ, ЕХАТЬ, ЕЗДИТЬ, ЛЕТЕТЬ, ЛЕТАТЬ, НЕСТИ, НОСИТЬ, ВЕЗТИ, ВОЗИТЬ. 2. Constructions of time "Когда ...?"; ”Во сколько ...?". 3. Numerals. Topics texts for reading, talking, listening: Ориентация в городе.
12	Topic 4. The plural of nouns, adjectives, pronouns. Changes	Types of compound sentence. Compound sentences with unions и, а, но, или; не только…, но и… Compound sentences, types of adjectival sentences with different unions and allied words: explanatory (что, чтобы, ли, кто, как, какой, чей, где, куда); determinative (который);

	in the cases. Types of compound sentence.	temporal (когда); conditional (если); causal (потому что, поэтому); purposeful (чтобы).
13	Conclusion.	Interim assessment. Summarising the results of the semester.

List of practical classes

Name of the practical classes	Number of ac. hours.
Introduction.	1
Topic 1. Phonetics. Introductory phonetic course. Word formation.	4
Topic 2. Intonation. Noun. The gender of nouns.	4
Topic 3. Noun. Nouns denoting profession. The concept of case. Verb. Infinitive.	6
Topic 4. Prepositional case of nouns	6
Topic 5. Verb. Conjugation of verbs. Present tense.	5
Topic 6. Genitive case of nouns.	6
Conclusion.	2
Topic 1. The concept of verb types. (Semester 2).	8
Topic 2. Dative case of nouns.	8
Topic 3. Prepositionless verbs of motion.	8
Topic 4. The plural of nouns, adjectives, pronouns. Changes in the cases. Types of compound sentence.	8
Conclusion.	2

Individual homework

Examples of individual homework:

2 semester:

Тема: «Дательный падеж».

Задание 3. Задайте вопросы по модели: Марина купила маме книгу. Кому Марина купила книгу? Что Марина купила маме?

1. Николай купил Ольге цветы. 2. Пётр купил брату часы. 3. Друг купил Джону учебник. 4. Родители купили дочери куклу.

Тема: «Глаголы движения».

Задание 1. Вставьте глаголы идти ходить; ехать ездить в нужной форме:

1. Куда ты ...? Я ... на работу. 2. Куда ты обычно ... в субботу? В субботу я обычно ... в спортивный зал. 3. Каждый день я ... в университет. 4. Тебе ... пешком 10 минут. 5. Вы ... на работу на метро или на автобусе? Обычно я ... на работу на метро. 6. Когда они ... в метро, они увидели друга.

24-DEC1-3202 MICROPROCESSOR TECHNIQUES

Course Objectives: ***On completion of this course the student will be able to:***

1. Obtain the necessary knowledge, skills and abilities in the field of microprocessor technology.
2. Acquire knowledge of the basics of architecture of modern microprocessors and microcontrollers; knowledge of the principles of design of microprocessor devices.
3. Use modern environments for development of embedded software for microprocessors and microcontrollers software for microprocessors and microcontrollers.
4. Acquire skills of programming microprocessor devices.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			3	3	1
CO2	3			3	3	1
CO3	3	2		3	3	3
CO4	3			2	3	2

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
1	Introduction	Structure and content of the discipline, its connection with other disciplines of the curriculum. The role and importance of microprocessors and microcontrollers in modern automated systems of measurement, control and management of technological processes of electronic production. Brief historical background on the development of microprocessor technology.
2	General information about microprocessor systems	Number systems. Classification of microprocessors by application areas and architectures. General information about microprocessor control systems. Basic signals and internal structure of generalised MP system. Logic element with the third state and interface microcircuits on its basis bus shapers and buffer registers. Programming language C - basic language constructions. Structure of a programme in the C language. Constants. Basic data types. Types of variables. Operations. Functions. Preprocessor. Using the C language for programming and microcontroller devices.
3	ARM family microcontrollers	Main characteristics of ARM family microcontrollers. Internal structure and pin of ARM family microcontroller. Programme model of ARM family microcontroller. The main registers of special functions. Clock generator, low-power mode. Reset signal shapers, power supervisors, watchdog timer. Parallel I/O ports, internal structure, programming methods. Time interval measurement, microcontroller timers, internal structure, programming methods. Formation of pulse width modulation signals. Use of interrupts in microprocessor systems. Sources of microcontroller interrupts. Serial input/output interface SPI. Microcontroller analogue and digital-to-analogue converters, characteristics, programming principles.

4	I/O facilities in microprocessor systems	Using parallel I/O to control discrete devices. Connection of keyboards to microcontrollers. General principles of serial information transfer. Synchronous and asynchronous information transfer. RS232 interface. Standard speeds of information transfer. RS485, RS422 interfaces. Synchronous interfaces IIC and SPI. Interfacing microcontrollers with devices for displaying discrete information, symbolic and graphic information. Connection of actuators to microcontrollers electromagnetic actuators, stepper and linear motors.
5	Storage devices	Basic information, purpose, classification. Microcircuits static operational memory devices (RAM). Internal structure, principles of functioning, clock diagram. Connection of static RAMs to the MP system. Microcircuits of dynamic random access memory devices (DRAM). Internal structure, principles of functioning, clock diagram of DRAM. Modern types of DRAM, prospects of development, principles of accelerated access to data in DRAM. Microcircuits of permanent memory devices (ROM). Internal structure, principles of functioning, clock diagram of ROM. Mask ROMs. ROM with UV and electric erasure. Connection of ROM to MP system.
6	Design of microprocessor systems	Basic principles of microprocessor control system design. Interfacing microcontrollers with external digital sensors and devices. Pairing of microcontrollers with external analogue-digital and digital-analogue converters. Improving noise immunity of microprocessor systems, peculiarities of designing printed circuit boards for microcontrollers. Selection of system components in accordance with the requirements for accuracy and speed.
7	Conclusion	Prospects of microprocessor technology development.

List of laboratory works

Name of the laboratory work	Number of ac. hours.
1. Introduction to the C compiler for PCs.	2
2. Studying the principles of developing and debugging C programmes using a compiler on a PC.	4
3. Studying a cross-compiler for ARM microcontroller.	2
4. Examination of I/O ports in output mode.	4
5. Examination of I/O ports in input mode.	4
6. External interrupts.	6
7. Timer.	6
8. Alphanumeric liquid crystal module	6
Total	34

Reference Books:

1. "ARM-Based Microcontroller Multitasking Projects", Dogan Ibrahim, Elsevier Science, 2020.
2. "ARM Microcontrollers Theory and Practical Applications", Hung Le,Cognella Incorporated ,2021

3. "Digital System Design - Use of Microcontroller", Shenouda Dawoud, R. Peplow,River Publishers,2022

24-DEC1-3203 MICRO-& NANOTECHNOLOGY PROCESSES

Course Objectives: ***On completion of this course the student will be able to:***

1. Attain knowledge in the field of application methods, removal and modification of matter at the micro and nanoscale, used in the components of solid-state electronics and integrated circuits creation.
2. Acquire the skills, knowledge and abilities required to master the basic processes and equipment used in traditional microtechnology, as well as specific processes that allow the formation of structures at the molecular level, based on the ability to self-organise, selectivity, anisotropy and the matrix principle.
3. Gain knowledge about the technology of creating integrated circuits; corpuscular photon impact on the target to create particle flows and produce films; physicochemical basis of surface processes; processes of forming films and coatings, as well as doping of semiconductors and lithography processes.
4. Choose optimal technological processes, their sequences, and to model physic technological processes allowing to form micro and nanostructures at the molecular and atomic levels.
5. Acquire the skills of working on technological equipment, as well as the skills of building technological processes based on a combination of the principles of control, self-forming and self-organisation of structures and chains of technological operations.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			3	3	2
CO2	3	1		3	3	3
CO3	3			2	3	2
CO4	3			2	3	
CO5	3	2		3	3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name of the topic of the discipline	Contents
1	Introduction	The origin and development of micro and nanotechnology. Development of the nanoindustry. Classification of micro- and nanotechnology processes. Nanotechnology by physic-chemical essence: mechanical, thermal, chemical, corpuscular-field; by type of process: deposition, removal, modification; nature of processes: total, local, selective, anisotropic; by method of activation: heat, radiation, field. Problems of purity and defectiveness of materials and structures.
2	Integrated circuit technology	Integral bipolar transistor. MOSFET transistors. CMOS inverter, stages of the technological process. Principles of planar technology. Methods for creating Oxide and nitride films. Peculiarities of the technological processes for manufacturing of large and ultra-large ICs. Super-large ICs.

3	Corpuscular-photon processes	Corpuscular and photon influence on a target to create particle streams and produce films. Ion and electron beams. Interaction processes of intense beams and plasma with condensed medium. Periodic discharges. High-frequency and very-high-frequency discharges. Combined circuits of technological processes with application of physical and chemical processes.
4	Physical and chemical bases of surface processes	Thermodynamics of surface processes. Adsorption processes on the solid surface. Energy of atomic particles interaction with the solid surface. Factors affecting adhesion. Electrophysical characteristics of contacting surfaces and interfaces. Physical and chemical basis for nucleation and growth of new phase. Analysis of homogeneous and heterogeneous nucleation. Influence of technological parameters of new phase nucleation on the structure of films. Conditions of epitaxial growth.
5	Film and coating formation processes	Classification of technological processes (TP) of thin film growth. Physical and chemical methods of thin film growth and stages of technological processes. Formation features of the components flow and their transfer for physical and chemical methods. Gas transmission processes; different precursor chemicals: halide and organometallic compounds. Obtaining organic films by the Langmuir-Blodgett method. Sol-gel technology. Molecular-beam epitaxy.
6	Technology, properties and diagnostics of nanomaterials	Allotropic forms of carbon. Fullerene, graphene, etc. Semiconductor low-dimensional structures. Fractal cluster. Dispersity. Ultradisperse systems. Methods of deposition from gas and liquid phase; liquid-phase epitaxy, electrochemical deposition of layers, deposition of mono- and multilayers of organic substances. Grow of carbon nanotubes and carbon materials from gas phase.
7	Semiconductor doping	Comparison of diffusion and ionic doping processes of materials. Ionic doping principles of semiconductors. Ion-beam mixing. Stopping power regularities of ions in matter. Depth distribution of embedded ions. Transverse displacement. Channeling. Formation of radiation defects in ion irradiation. Annealing of defects. Electrical activity of the impurity. Creation of buried dielectric layers. Ion implanter. Diagnostics of impurity distribution in the target.
8	Lithographic processes	The photolithographic process. Photoresists. Submicron lithography. Electron and ion lithography. Chemical etching of semiconductors and protective coatings. Ion plasma processing. Synchrotron radiation lithography, aspect ratio. Atom-probe methods of nanolithography, spatial resolution.
9	Conclusion	Building technological processes based on combination of control, self-forming, self-organization principles: adaptive synthesis of microelectronic structures, self-consistent chains of technological operations. Atomic molecular engineering.

List of laboratory work

Name of the laboratory works	Number of ac. hours.
1. Thermal deposition of conductive coatings	3
2. Deposition of metal films by magnetron sputtering	4
3. Deposition of oxygen-containing dielectric films by HF magnetron sputtering	3
4. Image formation by contact photolithography	4
5. Microprofiling of multicomponent materials. Ion etching	3
Total	17

List of practical classes

Name of the practical classes	Number of ac. hours.
1. Typical process of bipolar transistor formation by two-step diffusion method. Direct problem	6
2. Typical process of bipolar transistor formation by two-step diffusion method. Inverse problem	8
3. Quasi-neutrality parameters for low-temperature gas-discharge plasma	6
4. Analysis of ion-plasma sputtering and film deposition	8
5. Application of the ion implantation process for the formation of microelectronic structures	6
Total	34

Reference Books:

1. “Introduction to Nanoscience and Nanotechnology”,Charles P Poole & Frank J Owens, Wiley,2020. ISBN 978 9354240201
2. “Nanotechnology- An introduction to synthesis and applications of Nanomaterials”,Thomas Varghese, K M Balakrishnan, Atlantic publishers,2023, ISBN 978 8126916382
3. “Applied Nanotechnology The Conversion of Research Results to Products”, Jeremy Ramsden, Elsevier,2018
4. “Fundamentals of Nanotechnology”,Gabor L. Hornyak, John J. Moore, H.F. Tibbals, Joydeep Dutta ,CRC Press,2018

24-DEC1-3204 X-RAY STRUCTURAL METHODS OF MATERIAL RESEARCH

Course Objectives: ***On completion of this course the student will be able to:***

1. Understand the modern trends in the use of X-ray analysis methods
2. Acquisition of knowledge about the application features and specifics of X-ray research methods.
3. Acquire skills. of sampling and sample preparation of materials for research, adjustment and calibration of equipment.
4. Gain knowledge about the features of the application and specifics of X-ray research methods, about the device and principles of operation of the corresponding equipment.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3				2	2
CO2	3	3		3	3	2
CO3	3	3	1	3	3	2
CO4	3	3	1	3	3	2

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	X-ray radiation. X-ray diffraction and the Wolf-Bragg equation. Possibilities of the X-ray diffraction method.
2	Topic 1. Powder X-ray diffractometry	Methods of obtaining powder radiographs. Primary processing of radiographs. Profile functions, position and intensity of diffraction peaks. Qualitative phase analysis, working with powder databases. Identification of phases. Methods of qualitative phase analysis of two-phase and multiphase mixtures. Auto indexing. Casting a cell by Delaunay. Refinement of unit cell parameters. Atomic structure and construction of a theoretical diffractogram. Atomic structure refinement and quantitative phase analysis based on the Rietveld method. Representation of structural information in a Chemical Information File (CIF). Determination of the average size of crystallites (coherent scattering regions) and microstresses. Determination of particle size distribution (in the application to nanoscale crystals). Methods of high-temperature diffractometry. The dependence of the change in the parameters of the unit cell on the temperature. Determination of the coefficient of thermal expansion.
3	Topic 2. Single crystal diffractometry	Hardware design. Features of obtaining and processing diffractograms of single crystals. The Laue method. The rotating single crystal method. The widely divergent beam Method (SRP). X-ray diffraction analysis of small molecules and protein crystallography (MAD method). Databases of crystal structures.

4	Topic 3. Small-angle X-ray scattering	Types of studied samples and small-angle diffractograms. Hardware tasks and radiation generation schemes. Examples of designs of small-angle X-ray diffractometers and their blocks. Characteristic of Small-angle X-ray scattering graphs: methods of processing and analysis. Morphology and orientation of nanoparticles in nanocomposites. Particle and pore size distribution in nanomaterials.
5	Topic 4. X-ray fluorescence analysis	Spectrometric schemes in X-ray fluorescence analysis. The intensity of the fluorescence lines. Qualitative and quantitative analysis in X-ray fluorescence analysis. Types of X-ray fluorescence analysis (wave dispersion, energy dispersion, total external reflection, with a sliding selection angle, with a polarized beam, on sorption filters). Features of various types of excitation: synchrotron, particles, radioisotopes, X-ray tubes with polycapillary optics.
6	Topic 5. X-ray spectral microanalysis	Crystal-diffraction and energy-dispersion spectrometers. Selection of the target material. Efficiency of fluorescence excitation. Features and capabilities of X-ray spectral analysis. Features of sample preparation and the influence of elemental composition on the results of analysis.
7	Topic 6. X-ray tomography. X-ray flaw detection	X-ray computer, magnetic resonance imaging. Emission computed tomography: single-photon, positron. Neutron activation analysis. The method of flaw detection. Principles of X-ray transmission. Radiation receivers. Formation of a shadow X-ray image. X-ray machines for flaw detection. X-ray devices for medicine. Features of microfocus radiography. Basics of X-ray dosimetry.
8	Topic 7. Method of X-ray absorption spectroscopy	General classification of spectroscopic methods. Origin of absorption and emission spectra. ESCA method (electron spectroscopy for chemical analysis) as a direct experimental method for measuring the magnitude of the chemical bond energy. ESCA capabilities for surface analysis. Auger-electron spectroscopy and its capabilities for the analysis of light elements. Synchrotron radiation and XAFS (Fine structure spectroscopy of the X-ray absorption spectrum) and XANES spectroscopy of the near fine structure of X-ray absorption).
9	Conclusion	Prospects for the development of X-ray methods of materials research.

List of laboratory works

Name	Ac/h
1. Obtaining and primary processing of an X-ray diffractogram.	4
2. Qualitative and quantitative phase analysis of a multiphase system, and phase identification using a powder database (ICDD).	4
3. Autoindication of a monophase diffractogram and refinement of unit cell parameters.	4
4. Construction of a theoretical diffractogram based on structural data from the Cambridge Structural Bank and the ICSD Bank.	6
5. Determination of the sizes of coherent scattering regions and the construction of particle size distribution by various methods of mathematical processing of diffractograms.	4

6. Construction of the dependence of the change in the parameters of the unit cell on temperature and composition.	4
7. Determination of the elemental composition of samples by X-ray fluorescence analysis.	4
8. Determination of the elemental composition of samples by X-ray spectral microanalysis.	4
Total	34

List of practical classes

Name	Ac/h
1. X-ray radiation. X-ray diffraction and the Wolf-Bragg equation. Possibilities of the X-ray diffraction method. Single crystal diffractometry.	2.5
2. Small-angle X-ray scattering.	4
3. X-ray spectral microanalysis	2
4. X-ray tomography.	2
5. X-ray flaw detection.	2
6. Method of X-ray absorption spectroscopy. Prospects for the development of X-ray methods of materials research.	4.5
Total	17

Reference Books:

1. “X-ray Absorption Spectroscopy for the Chemical and Materials Sciences”, John Evans, Wiley, 2018.
2. “Small-Angle Scattering (Neutrons, X-Rays, Light) from Complex Systems Fractal and Multifractal Models for Interpretation of Experimental Data”, Eugen Mircea Anitas,Springer International Publishing , 2019
3. “Scanning Electron Microscopy and X-Ray Microanalysis”, Joseph I. Goldstein, Dale E. Newbury, Joseph R. Michael, Nicholas W.M. Ritchie, John Henry J. Scott, David C. Joy , Springer New York,2017
4. “X-Ray Fluorescence Spectroscopy for Laboratory Applications”,Michael Haschke, Jörg Flock, Michael Haller ,Wiley,2021

24-DEC1-3205 SEMICONDUCTOR HETEROSTRUCTURE TECHNOLOGY

Course Objectives: ***On completion of this course the student will be able to:***

1. Study the properties of materials used to produce optoelectronic devices on heterostructures, to study the basics of integrated microcircuit technology.
2. Develop skills of using the acquired knowledge to select optimal technological methods and parameters for manufacturing of heterostructures and devices
3. Acquire skills of assess the scientific significance and prospects of applied use of semiconductor hetero-structure technology in modern electronics and nanoelectronics.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			3	3	2
CO2	3	3			3	3
CO3	3	3			3	3

1- slightly, 2- moderately, 3-substantially

CONTENTS

No.	Name	Content
1	Introduction (1 ac.h.)	1. The subject of the course and its objectives. Information about the development of heterostructural-tour technology. The role of domestic scientists in this field. 2. Structure and content of the course, its connection with other disciplines of the curriculum and its importance in the training of a specialist in optoelectronics.
2	Topic 1. Basics of materials technology for heterostructures (8 ac.h.)	3. Crystal structure of semiconductor materials. 4. Methods of obtaining semiconductor crystals. 5. Doping of semiconductor materials. 6. Basic stages of technology of semiconductor heterostructures and devices based on them.
3	Topic 2. Materials used to produce heterostructures (6 ac.h.)	7. Basic materials: monoatomic semiconductors and semiconductor compounds. 8. Solid solutions.
4	Topic 3. Methods of obtaining of non-semiconductor films (13 ac.h.)	9. Technology of obtaining films of materials used for manufacturing ohmic contacts, enlightening and protective coatings for devices based on heterostructures.
5	Topic 4. Methods of production of heterostructures (7 ac.h.)	10. Classification and characteristics of methods.
6	Topic 5. Heterostructure post-processing methods (13 ac.h.)	11. Photolithography, electron beam and laser processing. Chemical and electrochemical machining.
7	Topic 6. Methods of studying the	12. Analysing methods of composition research. 13. Method using electron and ion beams.

	composition of heterostructures (9 ac.h.)	
8	Topic 7. Ion doping and diffusion in heterostructure technology (7 ac.h.)	14. Fundamentals of diffusion process. Use of diffusion in the technology of devices based on heterostructures. 15. Ion doping in the technology of semiconductor heterostructures.
9	Topic 8. Epitaxial methods of heterostructures production (19 ac.h.)	16. Liquid phase epitaxy. 17. Gas-transport epitaxy. 18. Vacuum epitaxy 19. Comparative characterisation of epitaxial methods of heterostructures production.
10	Topic 9. Technology of devices based on heterostructures (9 ac.h.)	20. Features of technology of devices based on heterostructures. Technology of heterolasers. Technology of hetero-LEDs. Technology of heterophotodetectors. Technology of solar cells based on heterostructures.
11	Topic 10. Technology of integrated circuits based on heterostructures (7 ac.h.)	21. Element base: bipolar and field-effect transistors on heterostructures 22. Features of IS technology on heterostructures.
12	Topic 11. Technology of quantum-dimensional heterostructures (8 ac.h.)	23. Methods of obtaining structures with quantum wells and quantum dots (molecular and MOCVD). 24. Technology of semiconductor devices based on quantum-dimensional heterostructures.
13	Conclusion (1 ac.h.)	25. Recent advances and major trends in heterostructure technology.

List of laboratory works

1. Methods of making ohmic contacts. Part 1. Photolithography.
2. Methods of creation of ohmic contacts. Part 2. Sputtering of multilayer contacts.
3. MOCVD of heterostructures.

List of practical classes

1. Introduction.
2. Crystal structure of semiconductor materials. Doping of semiconductor materials.
3. Main stages of semiconductor heterostructure technology and devices based on them. Methods of semiconductor crystals production.
4. Materials used to produce heterostructures.
5. Methods of obtaining non-semiconductor films.
6. Methods of obtaining non-semiconductor films.
7. Heterostructure post-processing methods.
8. Optical methods for the study of heterostructures.
9. Methods of studying heterostructures using electron, ion and X-ray beams.
10. Ion doping and diffusion in heterostructure technology.

11. Liquid phase epitaxy.
12. Gas transport epitaxy.
13. Vacuum epitaxy. Comparative characterisation of epitaxial methods.
14. Technology of heterolasers and hetero-LEDs.
15. Technology of photodetectors and solar cells based on heterostructures.
16. Technology of integrated circuits based on heterostructures.
17. Technology of quantum-dimensional heterostructures.
18. Conclusion.

Individual homework

The procedure for giving, completing and evaluating individual homework is determined by the methodology of current control.

The purpose of individual homework: preparation of a library-research paper and its public defence on one of the topics.

Content of the individual homework: During the semester each student presents a library-research paper. Abstract content: literature review on the topic of the assignment; Analysis of ways to improve the technology of obtaining materials, devices or research methods; Description of one of the device designs or technological process of obtaining and researching a material or device structure. The report on individual homework should be 25-30 pages and demonstration sheets.

Examples of topics of individual homework:

1. Materials for optoelectronic devices (production and properties)

1.1. «A^3B^5 Semiconductor compounds - comparative characteristics».
1.2. «Gallium arsenide».
1.3. «Semiconductor solid solutions».
1.4. «Solid solutions in the system aluminum-gallium-arsenic».
1.5. «Solid solutions in the system gallium-indium-phosphorus-arsenic».
1.6. «Modern semiconductor materials for optoelectronics».

2. Methods of semiconductor materials research

2.1. «Methods of measurement of basic physical parameters of semiconductor materials (conductivity, concentration, resistivity, mobility)».
2.2. «Electron microprobe analysis».
2.3. «Use electronic probe to study semiconductor devices».
2.4. «X-ray analysis».
2.5. «Local mass spectral analysis».
2.6. «Auger spectroscopy».

3. Methods of creating device structures

3.1. «The receiving instrument structures by LPE method».
3.2. «MBE method».
3.3. «MOCVD method».

3.4. «Photolithography».
3.5. « Elionika - application of electron and ion beams in technology of semiconductor devices».
3.6. «Ion doping of semiconductors».

4. Technology of semiconductor and optoelectronic devices

4.1. «Semiconductor lasers».
4.2. «LEDs».
4.3. «Photovoltaic devices».
4.4. «The solar energy converters».
4.5. «The display device».
4.6. «Optocouplers».
4.7. «The device fiber-optic communication lines».
4.8. «Semiconductor integrated circuits»

Reference Books:

1. "Synthesis, Modelling and Characterization of 2D Materials and Their Heterostructures", Dibakar Datta, Eui-Hyeok Yang, Grzegorz Hader, Junjun Ding, Elsevier Science, 2020.
2. "Handbook of Concentrator Photovoltaic Technology", Carlos Algora, Ignacio Rey-Stolle,Wiley,2016
3. "Epitaxy of Semiconductors Physics and Fabrication of Heterostructures",Udo W. Pohl ,Springer International Publishing,2020
4. "Metal Oxide-Based Heterostructures Fabrication and Applications", Bernabé Marí Soucase, Naveen Kumar, Elsevier Science, 2022

24-DEC1-3206 COMPUTER MODELING AND DESIGN OF MICROWAVE AND OPTICAL ELECTRONIC DEVICES AND DEVICES

Course Objectives: ***On completion of this course the student will be able to:***

1. Understand the fundamentals of numerical methods that are applied to problems of electro physics.
2. Acquire the skills to build multicomponent 3D models in CAD systems.
3. Modeling of microwave devices and analysis of electromagnetic fields and Calculation of solid-state microwave and optoelectronic devices
4. Acquires the skills of using modern software tools for modeling, research and design of microwave and solid-state devices.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			2	3	2
CO2	3			3	3	3
CO3	3			3	3	3
CO4	3	3		1	3	3

1- slightly, 2- moderately, 3-substantially

Contents

№	Name	Content
1	Introduction to electrodynamic modeling	Overview of modern programs for computer modeling of microwave and optical devices and devices (MEMFIS, Synopsys, CST Microwave Studio, Ansys HFSS, AWR Microwave Office, REMCOM). Applications of electrodynamic modeling. Fundamentals of the finite element method. Basic equations and boundary conditions. Introduction to EM CAD software. Program interface. Control panels. Assigning menu items. Creating and editing a model. Processing of simulation results. Setting of boundary conditions (magnetic, electric machine, radiation conditions, etc.). Establishing an artificial boundary for radiation problems. Construction of a finite element grid. Selection of the required frequency range (minimum and maximum frequency, frequency step). Setting the parameters of the construction material. Built-in library of materials. Changing the properties of the selected material. Installation of excitation sources (waveguide ports).
2	Fundamentals of electrodynamics	Electromagnetic field and its sources. Maxwell's equations in differential and integral form. Material equations. Boundary conditions. Power flow and Poynting's theorem. The theorem is replaced by news. Propagation of electromagnetic waves in the medium. Polarization. Derivation of the Helmholtz equation. Waveguide. Solutions of the Helmholtz equation for rectangular, cylindrical and coaxial waveguides. Modes and natural frequencies in waveguides.

3	The main types of microwave devices	Rectangular waveguide. Coaxial waveguide. Microstrip line. Coplanar line. The connection between the microstrips. Power dividers (directional coupler, Lange coupler, Wilkinson divider). Filters. Types of filters. Types of frequency response filters. The main parameters and characteristics. Filters on concentrated elements. Microstrip filters. A loop filter. Step impedance filter. Combined bandpass filter. Antennas. Antenna gain. Directional pattern. Impedance. Bandwidth. Polarization. The problem of impedance mismatch. Impedance matching methods.
4	Examples of numerical modeling in microwave electronics problems	Modeling of basic electrodynamic devices: rectangular waveguide, round waveguide, dielectric resonator, microstrip directional couplers, microwave filters. Dipole antenna. Frame antenna. Electromagnetic modeling of patch antennas of various configurations.
5	Introduction to modeling of semiconductor devices	Introduction to Synopsys Sentaurus TCAD. Finite difference method. Application of the finite element method to semiconductor problems. Overview of software modules (Sentaurus Device Editor, Sentaurus Device, Sentaurus Visual, Sentaurus Workbench). Creating a CAD model and setting boundary conditions using Sentaurus Device Editor. Syntax of the Sentaurus Device module. Calculation of the volt-ampere, volt-farad characteristics and transient characteristics of a semiconductor device. Visualization of simulation results.
6	Fundamentals of semiconductor physics	Electrical conductivity of semiconductors. Charge carriers in a weak electric field. Interaction with phonons, impurity atoms, defects. Mobility of electrons and holes. The condition of quasi-neutrality. Diffusion and drift of charge carriers. Einstein's attitude. Charge carriers in a strong electric field. Hot electrons. Avalanche multiplication in semiconductors. Electrical domains and current cords. The Gann effect. Equation of electric current density in semiconductors. The continuity equation. The Poisson equation. P-n transition in thermal equilibrium. The field effect in semiconductors. Schottky contact in thermal equilibrium. Ambipolar drift and ambipolar diffusion.. Haynes–Shockley experiment. Light absorption by semiconductors.
7	Fundamentals of physics of semiconductor devices	A diode with a p-n junction. Current-voltage characteristics of the diode. The voltage-frequency characteristic of the diode. Transient characteristic of switching a diode with p-n transition from forward to reverse bias. Schottky diode and its main characteristics. Ways to increase the breakdown voltage of Schottky diode. Bipolar transistor and its main characteristics. The field-effect transistor and its main characteristics. Thyristor. LED. Photo detector.

8	Examples of numerical modeling in solid-state electronics problems	A diode with a p-n junction. Characteristics of the calculation of current-voltage and voltage-frequency characteristics in Synopsys Sentaurus TCAD. Calculation of transient switching characteristics of the diode. Simulation of Schottky diode. 2D simulation of Schottky diode with guard rings. Simulation of a MOSFET transistor. Modeling of CMOS inverter. Modeling of a silicon photodetector. Modeling of a silicon avalanche photodiode.
9	Conclusion	Course overview. Summing up the results.

List of laboratory works

Name	Ac/h
1. Modeling of rectangular and circular metal waveguides	3
2. Calculation of the natural frequencies of dielectric resonators	3
3. Calculation of the microstrip filter	3
4. Calculation of dipole and frame antennas	3
5. Calculation of patch antennas of various configurations	3
6. Calculation of Schottky diodes based on silicon carbide with guard rings	2
Total	17

List of practical classes

Name	Ac/h
1. Investigation of rectangular and circular metal waveguides. Calculation of the critical wavelength for different types of modes	4
2. Calculation of natural frequencies of spherical and rectangular dielectric resonators	4
3. Calculation of the main characteristics of the filter based on the results of numerical modeling (working band, insertion loss, reliability, etc.)	4
4. Calculation of the dielectric permittivity of a layered dielectric structure based on the results of numerical simulation	4
5. Simulation of microstrip GPS antenna	4
6. Simulation of a directional coupler	4
7. Numerical simulation of a silicon diode with a p-n junction. Calculation of volt-ampere and volt-farad characteristics. Calculation of the transition characteristic.	4
8. Calculation of the Volt-ampere/4H-SiC Schottky diodes and determination of its breakdown voltage	4
9. Simulation of a diode with charge accumulation	4
10. MOSFET transistor simulation	4
11. CMOS inverter simulation	4

12. Modeling of a silicon photodetector	4
13. Modeling of a silicon avalanche photodiode	3
Total	51

Reference Books:

1. “Introduction to Electrodynamics, Volume 2”, David J. Griffiths, Cambridge University Press, 2017.
2. “Microwave Engineering”, David M. Pozar, Wiley, 2021.
3. “3D TCAD Simulation for CMOS Nanoelectronic Devices”,Yung-Chun Wu, Yi-Ruei Jhan ,Springer Nature Singapore,2017
4. “Physics of Semiconductor Devices”, Massimo Rudan ,Springer International Publishing,2017
5.“Computational Models in Engineering”, Konstantin Volkov, Intechopen,2020

ELECTIVE-I

24-DEC1-32071 COMMERCIALISATION OF RESEARCH AND DEVELOPMENT RESULTS

Course Objectives: ***On completion of this course the student will be able to:***

1. Analyse the market environment and manage projects at all stages of the life cycle.
2. Develop business plans for project implementation and action strategy; to predict the costs and expected results at all stages of the life cycle of the implemented project; to independently develop a financial plan of the project; to determine indicators to justify the effectiveness of research results.
3. Knowledge of the basics of business design in the field of development and implementation of programme projects; composition and structure of the business plan; costs associated with the creation and implementation of research results on the market; basic methods of assessing the effectiveness of research results.
4. Apply mathematical, natural and scientific, social, economic and professional knowledge to solve non-standard problems; to analyse the main indicators of the enterprise's activity; to predict costs and expected results at all stages of the life cycle of manufactured products; to carry out technical, economic and functional analysis of manufactured products; to apply indicators to substantiate the effectiveness of research results.
5. Master the skills of effective management of software and project development; gathering information necessary for market assessment, project efficiency evaluation, as well as independent work and self-organisation and presentation of projects.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3				3
CO2		3				3
CO3		3				3
CO4		3		3		3
CO5		3	3			3

1- slightly, 2- moderately, 3-substantially

Contents

No	Name	Content
1	Introduction	The concept of innovation, commercialisation of innovation, innovative products. Business design.
2	Business plan: structure and content	Resume. Description of the enterprise, projected products or services provided. Analysis of the market and competitors. Marketing plan. Production plan. Organisational plan. Financial plan. Risk assessment.
3	Economics and organisation of R&D	Purpose and tasks of economic justification in the development of new equipment and technology. Organisation of R&D: stages, phases, planning of R&D. Research of the market environment of the innovation project. Types of costs at the stages of R&D. Calculation of R&D cost.

4	Economics and organisation of production of innovative products	Economics of production. The concept of costs and their types. Classification of costs of production. Cost of production. Methods of calculation of cost. Calculation of costs by costing items. Determination of the break-even point. Factors determining the value of the cost of production. The price of products. Revenue, profit and profitability of production. Organisation and planning of production.
5	Economics and organisation of service of innovative products	Modern tendencies of service maintenance of innovative products. Pre-sale service. After-sales service. Organisation of repair of innovative products. Quality management.
6	Economic efficiency of innovative projects	Principles of evaluation and types of efficiency of investment projects. Financial planning. The concept and purpose of discounting. Methods of evaluation of economic efficiency of investment projects. Accounting of risks of innovative and investment projects realisation.
7	Conclusion	Summarising the results of the discipline and their practical application.

List of practical classes

Name	Ac/h
1. Introduction to business design	1
2. Formation of the composition and structure of the business plan	2
3. Analysing the market and competitors. Marketing planning.	3
4. Production plan. Determination of investment needs.	2 2
5. Production plan. Calculation of current costs of production of R&D products	2 2
6. Organisational plan	3
7. Financial plan. Evaluation of project efficiency. Risk analysis	3 3
8. Formation of a report on commercialisation of R&D results	1
Total	17

Individual homework

Individual homework is a study project developed in the form of a business plan. The product of the project (the result of research and development, planned for implementation in production and market promotion) is proposed by the Master's student independently, based on his/her scientific interests and (or) the problematics of his/her Master's thesis.

The individual work should include mandatory sections corresponding to the structure of the business plan. The work is carried out throughout the course of study of the discipline, step by step. Materials of the sections are submitted to the teacher as they are completed, after passing the relevant topics of the discipline. Upon completion of the work is carried out defence, which includes presentation and discussion of the finished project.

Mandatory sections of the work:

- Summary

- Product description
- Market analysis
- Marketing plan
- Production plan
- Financial Plan
- Organisational plan
- Risk analysis and assessment

- Formalisation and defence of the project.

Reference Books:

1.“Project Management for Engineering, Business and Technology”, John M. Nicholas, Herman Steyn, Taylor & Francis 2020.
2. “Principles of Marketing”,Philip Kotler, Gary Armstrong, Lloyd C. Harris, Hongwei He ,Pearson,2019
3. “Principles of Accounting Volume 2 - Managerial Accounting”,Mitchell Franklin, Patty Graybeal, Dixon Cooper , 12th MediaServices,2019
4. “Project Financing: Analyzing And Structuring Projects”,Carmel De Nahlik, Frank J Fabozzi,World Scientific Publishing,2021

ELECTIVE-I

24-DEC1-32072 FOREIGN ECONOMIC ACTIVITY OF ORGANISATIONS

Course Objectives: ***On completion of this course the student will be able to:***

1. Form the necessary knowledge, skills and abilities in the field of realisation of foreign economic relations taking into account the state policy.
2. Learn the principles and tools of state regulation of foreign economic activity; principles of foreign economic activity at different levels of the economy; types and forms of foreign economic activity of a modern enterprise.
3. Analyse the foreign economic activity of an enterprise and its efficiency; analyse the state of the foreign target market and assess the competitive advantages of an enterprise in it; formulate the main provisions of a foreign economic contract and calculate the retail prices of imported goods.
4. Master the skills of developing a matrix of competitive advantages of the firm, preparation and execution of a foreign economic transaction, methods of assessing the effectiveness of foreign economic activity of the enterprise.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					3
CO2	3					3
CO3	3		2			3
CO4	3			2		3

1- slightly, 2- moderately, 3-substantially

Contents

No	Name	Content
1	Introduction.	Purpose, subject and objectives of the course. Course structure and labour intensity by type of workload. Analysis of the course literature.
2	Development of foreign economic activity in the world economy.	The concept of the world economy, its structure. Subjects of the world economy. International economic mechanism. The main stages of formation of the world economy. World resources and their distribution between countries. International division of labour. International economic relations. Classification of countries by economic potential and level of social and economic development. Russia's/India’s place in the system of world foreign economic relations.
3	Foreign economic activity of organisations.	Foreign economic activity of the enterprise: concept, types, types. Economic prerequisites for the development of foreign economic activity of the enterprise. Foreign economic activity of Russian/Indian enterprises. Activities of foreign firms in Russia/India. Functions of foreign economic activity. Foreign economic relations of Russia/India. Participants of foreign economic activity. Residents. Intermediaries in foreign economic activity.
4	State regulation of foreign economic activity in the Russian	The system of state regulation of foreign economic activity. Models of foreign economic relations of the country and types of state intervention in the foreign economic sphere. Structure of the

	Federation.	mechanism of state regulation of foreign economic activity. Elements of the mechanism of state regulation of foreign economic activity. Foreign economic policy of the state and its components. Legal regulation of currency and financial relations. Regulation of foreign investments in the Russian Federation/India. Russian/Indian specifics of regulation of international scientific-technical and innovation co-operation.
5	Essence, classification and organisation of foreign economic operations and transactions.	Foreign economic operations. Organisation and techniques of export-import operations with direct links between counterparties. Features of the organisation of foreign economic operations with the use of intermediary services. Types of trade and intermediary relations. Classification of foreign trade operations: by directions of trade, by types of goods and services, by degree of readiness of goods, by organisational forms of trade, by methods of trade. Methods of entering the foreign market. The main stages of a typical commercial transaction.
6	Sales and purchase contract as the main document in foreign economic activity.	Theoretical and normative basis of international contracts. The content of the terms and conditions of a foreign trade contract. Typical mistakes when concluding a contract. Basic conditions of supply and the Incoterms system.
7	Organisation and management of external economic activity of the enterprise.	The procedure of state registration of Russian/Indian participants of foreign economic activity. Foreign economic strategy of the enterprise. Assessment of competitiveness of the enterprise and its products in the foreign market. Pricing in the foreign economic activity of the enterprise. International marketing and its role in the foreign economic activity of the enterprise. Partner selection in the foreign economic activity of the enterprise. Organisation of management of foreign economic activity of the enterprise. The system of relations of the participant of foreign economic activity with third-party organisations. Evaluation of the efficiency of foreign economic activity of the enterprise.
8	Conclusion.	Generalisation of the results of the discipline and their practical application.

List of practical classes

Name	Ac/h
1. Russia/India in the system of international economic relations.	2
2. Calculation and payment of taxes by residents and non-residents.	2
3. Regulation of foreign economic activity at different levels.	4
4. Customs regulation of foreign economic activity.	2
5. Foreign exchange terms and conditions of contracts. Foreign trade crediting.	4
6. Economic analysis of foreign economic activity of the enterprise.	3
Total	17

Library-research paper

Background and requirements: The topic of the abstract is chosen by each student independently, or in agreement with the teacher.

The content of the abstract includes: content, introduction, theoretical and practical sections (two sections), conclusion (conclusions), list of references and appendices (if available). The content of the abstract should correspond to the questions posed, as well as have logically complete conclusions, generalisations, practical recommendations.

Topics:

- International specialisation and co-operation.
- Theories of world trade.
- Features of the modern world market.
- Import and export prices and their ratio.
- World trade and economic growth.
- Structure of the freight forwarding contract.

Reference Books:

1. The Palgrave Handbook of Digital Russia Studies", Daria Gritsenko, Mariëlle Wijermars, Mikhail Kopotev, Springer International Publishing, 2020.
2. "Foreign Direct Investment (FDI) and Ease of Doing Business in India", Madhusudana H S, New Century Publications 2019 November. ISBN 13-978-8177084832
3. "Foreign Direct Investment – A Practitioner's Guide". – The Institute of Company Secretaries of India
4. "Corporate Governance in Russia",Alla Dementieva, Elena Zavyalova, De Gruyter,2020

24-DEC1-3208 INTERNSHIP (RESEARCH PROJECT)

FIELD EXPERIENCE

Manufacturing practice along with the expansion and the further accumulation of professional knowledge and skills in the field of independent scientific research and design on the program “Microwave photonics and fiber optics” can solve problems that are closely related to the theme of the future master’s thesis, namely the launch of the Information Support dissertation, research and development relevant to the thesis of software packages, new types of equipment and machinery.

Aims and objectives of the state final attestation

The aim of an internship (design and engineering practice) of students is the development and consolidation of knowledge, skills and abilities obtained during classroom studies, as well as the acquisition of professional competencies in the field of independent design and engineering work.

Internship solves the tasks related to the preparation for the design and construction part of the future research project (graduate qualification work (GQW)) of a master's student, namely:

1) introduction to the main types of work within the framework of design and engineering.

2) acquisition of experience of independent design and engineering within the framework of the topic of the master's thesis.

3) study and development of the software intended for designing elements and devices of photonic radar and fiber optics.

Gaining knowledge and skills in working with application program packages, new types of research, technological and production equipment.

The required skills to generate a list of sources of information on the thesis topic, to find out and pre-order hard-to-access sources (including patent information), as well as hard-to-access apparatus and equipment.

Develop skills and methods of work on research, technological and other types of apparatus and equipment to solve the tasks of both industrial and pre-diploma practice.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3				3
CO2		3				3
CO3		3				3

1- slightly, 2- moderately, 3-substantially

PRACTICE CONTENT

Practice is carried out on a contractual basis in third-party organizations (enterprises, firms) in the profile of the area of study or at the graduate departments and other structural units of the University. In departments, where the internship takes place, workplaces are allocated for the performance of individual tasks under the program of the practice.

The content of the internship is determined by the graduating departments on the basis of Educational Standards of Higher Education, with consideration of the interests and capabilities of the subdivisions (departments, laboratories, scientific groups, etc.) in which it is carried out. The specific content of the student's work during the period of practice is planned by the management of the unit in which it is carried out. And is reflected in the individual assignment for practice.

The timing and duration of the internship shall be established in accordance with the study plans and the annual calendar academic schedule.

During the practice period, students are subject to all internal regulations and safety rules that are established in the subdivision and at the workplaces.

Sl. No.	Sections (stages) of practice	Types of work in practice, including independent student work	Forms of current monitoring
1	Preparatory	1. Development of individual assignment. 2. Organizational meeting to explain the aims, objectives, content and procedure of the internship. 3. Introduction to the place of practice.	Control of organizational issues, aims, objectives and content of assignments.
2	Main	1. Collection and processing of regulatory and legal, production and technological information. 2. Execution of individual assignments.	Results of individual assignment fulfillment.
3	Final	1. Compilation and execution of the report on practice. 2. Defense of the report (interim certification).	Feedback from the head of practice from the enterprise (organization). Verification of the report on practice.

PRACTICE MANAGEMENT

Practice management is carried out by the practice supervisor from CUSAT and by the practice supervisor from the organization (enterprise), if the practice is carried out in the organization (enterprise).

The head of the organization develops individual tasks, content and planned results of practice, provides workplaces, provides safe conditions for the practice of students, meeting the sanitary rules and requirements of occupational safety, provides instruction of students on introduction to the requirements of occupational health and safety, fire safety, as well as the rules of internal regulations. After the end of the internship evaluates the work of the student and gives feedback. The feedback evaluates the attitude to work, completeness of the completed task.

Head of practice from the university agrees individual tasks for students, performed during the internship at the enterprise and develops individual tasks to be performed during the internship at CUSAT. Controls the observance of the terms of practice and compliance of its content with the established requirements, provides methodological assistance to students in the performance of individual tasks, collection of materials for the report and materials that can be used for research work and writing a graduate qualification work, evaluates the results of the practice of students.

LIST OF SAMPLE INDIVIDUAL ASSIGNMENTS

Task 1 Determination of the Landau-Khalatnikov coefficients from the hysteresis curve.

Task 2 Modeling the Thermal Modes of a MOSFET Transistor.

Task 3 Simulation of solitons in the medium of nonlinear oscillators.

Task 4 Experimental study of the bistability of a spin-wave active ring resonator.

Task 5 Investigation of self-organization elements in the environment of coupled fractional order Lorentz oscillators.

FORM OF FINAL REPORTING ON PRACTICE

The document on the results of the practice of the student is a report. The student gives a brief description of the place of practice, tasks and operations that he performed during the internship.

Terms of delivery and defense of reports on practice are established in accordance with the calendar schedule of the educational process.

The report shall be technically competent, may be illustrated with sketches, schemes, tables, photographs. The report together with the collected materials can be used in the future in writing the final qualification work.

Internship report can also be defended at the place of work. In this case, the student presents a report to the department with an assessment, with signature of the head of practice from the enterprise. The assessment is taken into account when defending the report at the university. The final grade is entered in the statement and the credit book by the head of practice from the university.

SEMESTER – III

24-DEC1-3301 FOREIGN LANGUAGE / RUSSIAN AS A FOREIGN LANGUAGE

Course Objectives: ***On completion of this course the student will be able to:***

1. Gain knowledge of phonetic, lexical and grammatical and norms of the modern Russian language.
2. Develop the skills of making statements based on the intentions arising in simple situations of a standard type.
3. Achieve linguistic, social-cultural and communicative skills and abilities that enable foreign students to solve communicative tasks in academic, every day and cultural spheres of communication.
4. Obtain knowledge of grammar, morphology and syntax of the Russian language to the extent of the curriculum of the elementary certification level.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			3
CO2			3			3
CO3			3			3
CO4			3			3

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
1	Topic 1. Types of verb (continuation of the topic). (Semester 3)	1. Type of verb. Imperfective and perfective forms (present, future and past tenses). Pairs of verbs Imperfective and perfective forms. The form of difficult Imperfective verbs. Verbs "начинать(ся) начать(ся)". The use of perfective verbs in conveying sequential actions. Use of perfective and imperfective verbs. Impersonal sentences: past tense. Нравиться – понравиться. 2. Topics of texts for reading, talking, listening: Университет. День рождения.
2	Topic 2. Instrumental case of nouns and adjectives.	1. Instrumental case of adjectives, possessive and indicative pronouns (singular) Compound sentences with the conjunction "чтобы". 2. Topics of texts for reading, talking and listening: Профессии. Твое хобби. Кто чем интересуется. Выбор профессии, места работы или учебы. Приглашение в гости.
3	Topic 3. Expressing time, place, and purpose. (Continuation of topic).	1. Expression of place: где? The prepositional case of place with prepositions в, на. The genitive case of place place with the prepositions около, у, недалеко от, справа от, слева от, напротив, посредине, вокруг. Instrumental case with the prepositions над, под, перед, за, между в значении места. 2. Direct and indirect speech. Объяснить, сообщить, (рас) сказать что…, ответить кому?, написать кому? , передать кому?, спросить кого? , задать вопрос кому?, сказать кому?, чтобы…, посоветовать, пообещать кому? + инф,,

		предложить, попросить кого?, чтобы… . 3. Expression of purpose. The Instrumental case with preposition за to indicate purpose. 4. Topics of texts for reading, talking and listening: Профессии. Твое хобби. Кто чем интересуется. Выбор профессии, места работы или учебы. Приглашение в гости.
4	Topic 4. Basic verbs of motion with prefixes.	1. Verbs of motion. Use of verbs of motion with prefixes of spatial meaning. Transitive verbs of motion. 2. The construction "За сколько времени ...?". 2. Topics of texts for reading, conversations: В городе.
5	Topic 5. Summarising the material learnt.	1. Repeat and summarise the material learnt. Repeat the cases. Repeat personal and possessive pronouns. Repeat types of verbs, verbs of motion. Repeat the forms of verbs of the past and future tense. 2. Theme: "Свободное время, отдых, интересы".
6	Conclusion.	Final assessment. Summarising the results of the course.

List of practical classes

Name of the practical classes	Number of ac. hours.
Introduction.	1
Topic 1. Phonetics. Introductory phonetic course. Word formation.	4
Topic 2. Intonation. Noun. The gender of nouns.	4
Topic 3. Noun. Nouns denoting profession. The concept of case. Verb. Infinitive.	6
Topic 4. Prepositional case of nouns	6
Topic 5. Verb. Conjugation of verbs. Present tense.	5
Topic 6. Genitive case of nouns.	6
Conclusion.	2
Topic 1. The concept of verb types. (Semester 2).	8
Topic 2. Dative case of nouns.	8
Topic 3. Prepositionless verbs of motion.	8
Topic 4. The plural of nouns, adjectives, pronouns. Changes in the cases. Types of compound sentence.	8
Conclusion.	2
Topic 1. Types of verb (continuation of the topic). (Semester 3)	8
Topic 2. Instrumental case of nouns and adjectives.	6
Topic 3. Expressing time, place, and purpose. (Continuation of topic).	8
Topic 4. Basic verbs of motion with prefixes.	8
Topic 5. Summarising the material learnt.	2
Conclusion.	2
Total	102

Individual homework

Examples of individual homework:

3 semester:

Тема: «Виды глагола».

Задание 2. Закончите предложения, используя правильную форму глаголов дарить подарить; лежать класть положить; стоять ставить поставить: 1. Что ты ... своей подруге на день рождения? Я ... ей русские сувениры. 2. Я не знаю, что ... друзьям. ... им книги о русском искусстве. 3. Что вы обычно ... родителям на Новый год? Обычно мы ... книги или бытовую технику. 4. Учебник ... на столе. 5. Обычно я ... в чай 2 ложки сахара. 6. ... мне, пожалуйста, немного салата. 7. Когда он ... на диване, он думал о своей девушке. 8. На остановке автобуса .. студенты. 9. Где у вас ... телевизор? 10. Давай ... цветы в воду!

Тема: «Глаголы движения».

Задание 1. Образуйте временные конструкции с предлогом ”на” + в.п. и следующими глаголами: прийти, приехать, заехать, зайти, уйти, выйти. оставьте предложения с полученными конструкциями.

ELECTIVE-II

24-DEC1-33021 MULTIJUNCTION SOLAR CELLS BASED ON III -V COMPOUNDS

Course Objectives: ***On completion of this course the student will be able to:***

1. Understand the principles of construction of semiconductor photo transformation nano heterostructures based on AIIIBV compounds
2. Understand the principles of operation of optoelectronic semi-conductor devices, in particular, photovoltaic
   solar energy converters.
3. Analyze the physical processes occurring in p-n junctions, including contact phenomena at the semiconductor-semi-conductor, polyconductor-dielectric, semiconductor-metal interface
4. Acquire the skills in developing the design of multi-junction solar cells based on AIIIBV compounds

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1			2	
CO2	3	1			2	1
CO3	3	3			3	2
CO4	3	2			3	3

1- slightly, 2- moderately, 3-substantially

Contents

№	Name	Content
1	Introduction	The structure and content of the course, its connection with other disciplines of the curriculum and the importance in training a specialist in the field of semiconductor solar power engineering. Overview of the main trends in the development of nanoheterostructural solar cells.
2	Properties of solar radiation	The influence of the atmosphere on the spectral composition of solar radiation. Standards of the solar spectrum. Classification of solar cells by the type of materials used, methods of production and conditions of use.
3	Photovoltaic conversion efficiency	The main factors characterizing the efficiency of photovoltaic conversion in a solar cell. Efficiency values implemented in various types of solar cells. Features of the design and application of solar cells for the conversion of concentrated solar radiation.
4	Physical methods for reducing optical and recombination losses in solar cell structures	Using the phenomenon of optical interference. Using zone structure effects and integrated potential barriers.
5	Cascade nanoheterostructural phototransverters based on AIIIBV compounds	Mechanical and monolithic coupling of cascades. The basic structure of a monolithic cascade photo converter. Promising options. Tunnel diodes: structure, volt-ampere characteristic, tunneling current limit. Application of nanoheterostructures in layers of tunnel diodes. Solar cells based on arrays of quantum wells and quantum dots. Metamorphic inverse solar cells.

6	Ohmic losses in solar cells	Sources of ohmic losses and methods of their minimization. Distributed ohmic losses. Theoretical consideration of the effect of ohmic losses on the type of current-voltage characteristics and the efficiency of photoelectric conversion. Leaks in the p-n junction, their effect on the type of current-voltage characteristic.
7	Conclusion	Advantages of concentrator photovoltaic systems determined by physical, technological and economic aspects.

List of laboratory works

Name	Ac/h
1. Investigation of optical properties of solar cell layers	5
2. Investigation of the current-voltage characteristics of solar cells	6
3. Investigation of temperature dependences of volt ampere characteristics of solar cells	6
Total	17

List of practical classes

Name	Ac/h
1. Calculation of the upper transition parameters based on GaInP	5
2. Calculation of the parameters of the average transition based on GaAs	6
3. Calculation of the parameters of the lower transition based on Ge	6
Total	17

Reference Books:

1. “Semiconductor Materials for Solar Photovoltaic Cells”, M. Parans Paranthaman, Raghu N. Bhattacharya, Winnie Wong-Ng, Springer International Publishing, 2015.
2. “Photoelectrochemical Solar Cells”, Nurdan Demirci Sankir, Wiley, 2018.
3. “Photovoltaic solar energy generation”, Adolf Goetzberger, Volker Uwe Hoffmann, Springer, 2015.

ELECTIVE-II

24-DEC1-33022 LASER TECHNOLOGIES IN MANUFACTURING OF SOLAR MODULES

Course Objectives: ***On completion of this course the student will be able to:***

1. Acquire knowledge about the physical foundations of laser micro-processing of materials, the principles of construction and design features of technological laser installations, the main areas of application of technological lasers in microelectronics and the production of thin-film solar modules.
2. Form skills to determine the required characteristics of technological lasers in the micro-processing of materials and in the production of thin-film solar modules and to configure and competently operate technological lasers.
3. Acquire the skills of the simplest engineering calculations of technological lasers and their output parameters.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1			3	2
CO2	3	3			3	3
CO3	3	3			3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	The structure and content of the discipline. Its relationship with other disciplines of the curriculum. Brief historical background on the development of laser technologies.
2	Topic 1. Physical fundamentals of laser microtechnologies	Basic physical processes of laser micro-processing. Necessary laser parameters for micro-processing of materials. The main types of lasers used for micro-processing.
3	Topic 2. Main applications of laser micro-processing	Laser cutting. Laser scribing. Laser drilling of micro-holes. Laser marking and engraving. Laser micro-welding and micro-soldering.
4	Topic 3. Application of laser microtechnologies in photovoltaics	Scribing and structuring of crystalline solar cells. Application of laser micro-processing in the production of thin-film solar modules.
5	Conclusion	Prospects for the development of laser microtechnologies and microprocessing.

List of laboratory works

Name	Ac/h
1. Setting up the optical resonator of the laser.	5
2. Energy characteristics of helium neon laser radiation	4
3. Investigation of a laser beam scanning system based on an acousto-optic deflector.	4
4. Laser marking of thin-film coatings using a nitrogen laser.	4
Total	17

List of practical classes

Name	Ac/h
1. The device of modern technological lasers	2
2. Lasers for marking	2
3. Lasers for micro-welding	2
4. Lasers for drilling micro-holes	2
5. Cutting lasers	2
6. Lasers for scribing sapphire substrates	2
7. Thermal deformations during laser cutting	2
8. Thermal lens in resonators of high-power Nd:YAG lasers	1
9. Laser engraving.	2
Total	17

Library-research paper

Initial data and requirements:

1. The volume of abstracts should be at least 15 pages (font — New Times Roman, size 14, interval - 1.5), maximum 30 pages.
2. The abstract should consist of the following sections: Abstract, Introduction, Main part, logically divided into subsections, Conclusion, References
3. Library-research paper should be issued in accordance with SCI indexed, while special attention should be paid to the design of the list of cited scientific literature, which should contain at least 7 sources, a maximum of 30.
4. Library-research paper is submitted to the teacher in electronic form.

Topics:

No.	Name
1	Laser “peeling” (lift-off technology) of electronic microchips
2	Excimer laser and their applications for industrial material processing
3	Multi pulsed laser micromachining of materials
4	Basic physical processes in laser processing of materials. Mathematical description of thermal processes during laser impact
5	Laser polishing
6	Laser drilling and hole punching
7	Laser thermohardening
8	Laser thermal splitting technology
9	Laser structural modification of materials
10	Laser scribing

Report

Reports should be structured in such a way that their topic is disclosed. This means that each report should consist of several semantic parts. Including: an introduction (which provides information about the physical principles of operation of a particular laser or laser system), the main content part (about the device and applications of a particular laser or laser system) and a conclusion.

The duration of the report should be 25-30 minutes.

The report is expected to look forward to the results in the form of a computer PowerPoint presentation (in the number of 2025 pcs.) and video (at the request of the speaker).

List of topics of reports:

1. Femtosecond Laser Technologies;
2. Laser stereolithography;
3. Laser powder cladding;
4. Laser sintering;
5. Laser application in nanolithography;
6. Laser application in nuclear industry;
7. Laser application in microelectronics;
8. The design and output characteristics of lasers for technological applications;
9. Laser marking;
10. Laser engraving.

Organization and educational and methodological support of independent work

The study of the discipline is accompanied by independent work of students with literary sources that are recommended by the professor and information resources of the Internet. Planning time to study the discipline is carried out for the entire period of education, while providing for regular repetition of the material passed. Within the framework of extracurricular independent work, students need to regularly supplement the material outlined in lectures with information from literary sources. At the same time, it is advisable to make a summary of the main provisions that are based on the study of the recommended literature, terms and definitions necessary for the development of sections of the discipline.

Current	Approximate labor intensity, ah
Work with lecture materials, with educational literature	14
Advanced independent work (study of new material before its presentation in the classroom)	0
Independent study of discipline sections	0
Doing homework, homework tests	0
Preparation for laboratory work, practical and seminar classes	10
Preparation for control works, colloquiums	6
Execution of calculation and graphic works	0
Execution of a course project or course work	0
Search, study and presentation of information on a given problem, analysis of scientific publications on a given topic	10
Work on an interdisciplinary project	0
Analyzing data on a given topic, performing calculations, drawing up diagrams and models based on the collected data	0

Preparation for the test, differentiated test, Graded test	35
TOTAL	75

Reference Books:

1. "Technology, Manufacturing and Grid Connection of Photovoltaic Solar Cells", Guangyu Wang, Wiley, 2018.
2. "Advances in Laser Materials Processing, Technology, Research and Applications", J. R. Lawrence, Elsevier Science, 2017.

ELECTIVE-III

24-DEC1-33031 LASER PHYSICS AND NONLINEAR OPTICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Study the basic laws of laser physics and nonlinear optics describing the phenomena of spontaneous and stimulated emission, laser generation, methods of measurement and description of laser beam propagation and its transformation in a nonlinear medium.
2. Develop skills in calculating parameters of laser radiation, optical converters and modulators.
3. Master the acquired skills to assess the scientific significance and prospects of applied physics of lasers and nonlinear optics in modern optoelectronics.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3				3	
CO2	3	2		2	3	2
CO3	3	2		3	3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction (1 ac. h)	Introduction to the aims and objectives of the course, brief overview of the topics covered.
2	Section I. Basics of laser physics. Topic 1. Light amplification in matter (6 ac. h)	Absorption and amplification of light. Spontaneous and stimulated transitions. Einstein coefficients. Inverse population. Condition of amplification. Two-, three- and four-level laser schemes.
3	Topic 2. Laser resonator (6 ac. h)	Theory of optical resonators. Fabry-Perot modes. Resonance frequencies. Spectral distance between neighbouring modes. Reflection and wave propagation at the end of a waveguide. Radiation losses. Directional diagram of laser radiation. Diffraction divergence of radiation.
4	Topic 3. Velocity equations and dynamic characteristics of lasers (7 ac. h)	Composition of velocity equations, their physical meaning. Stationary solution of velocity equations. Balance of carriers and photons. Saturation of amplification at generation threshold. Threshold characteristics. Dynamic characteristics of lasers. Modulation of goodness of fit. Synchronisation of modes.
5	Topic 4. Measurement of laser radiation parameters (7 ac. h).	Basic parameters of laser radiation and methods of their measurement: mode spectrum, angular divergence of radiation, coherence length, polarisation, energy and power, pulse duration, spectroscopy of laser radiation.
6	Section II. Nonlinear optics. Topic 5. Theoretical nonlinear optics (7 ac. h).	Mechanisms of optical nonlinearity. Violation of the superposition principle for strong light waves in a medium. Material equation of nonlinear medium. Nonlinear polarisation. Nonlinear susceptibility. Classical model of nonlinear medium - ensemble of nonlinear oscillators.

7	Topic 6. Main effects of nonlinear optics (7 ac. h).	Optical second harmonic generation. Intracavity second harmonic generation. Forced Raman scattering of light. Self-focusing of light.
8	Topic 7. Optical parametric oscillator (7 ac. h).	Optical parametric oscillator. Basic principles of operation and application.
9	Topic 8. Nonlinear optics and modulation of laser radiation (8 ac. h).	Electro-optical effect. Acousto-optical effect. Faraday effect. Nonlinear effects in optical fibres.
10	Topic 9. Light propagation in crystals (8 ac. h).	Dielectric properties of an anisotropic medium. Propagation of plane waves in a uniaxial crystal. Birefringence. Conical refraction.
11	Topic 10. Optics of femtosecond laser pulses (8 ac. h).	Extremely short pulses of light and superstrong light fields. Generation of femtosecond light pulses. Femtosecond laser im-pulses in spectroscopy.
12	Section III. Perspective directions of development of laser physics and nonlinear optics. Topic 11. Light pressure and optical manipulation (7 ac. h).	The pulse of a light wave. Measurement of light pressure. Lebedev's experiments. Optical levitation of small transparent particles. Ashkin's experiments. Forces of light pressure. Light pressure along the beam. Light pressure across the beam. Optical trap. Optical tweezers and their applications.
13	Topic 12. Generation of terahertz radiation (9 ac. h).	Generation of difference harmonic. Phase synchronism condition. Generation of terahertz radiation by light rectification. Optical keys. Dember effect.
14	Topic 13. Generation of non-diffracting (Bessel) light beams (9 ac. h).	Non-diffracting (Bessel) light beams. Physical bases of absence of the diffraction divergence of optical beams. Methods of generation of Bessel beams. Conical lens (axicon). Generation of Bessel beams using semiconductor radiation sources.
15	Topic 14. Promising applications of lasers and nonlinear optics devices (10 ac. h).	Students complete individual homework on this topic.
16	Conclusion (1 ac. h)	The main conclusions of the course in general. Discussion of the use of the material reviewed in the study of subsequent disciplines.

Methodological instructions for studying the discipline material

The study of the discipline topics is carried out by students independently with subsequent discussion at practical classes (seminars). In addition, each student performs individual homework (library-research paper) and makes a report on its materials lasting 30-40 minutes. The report is carried out at the expense of the time devoted to practical classes.

List of practical classes

1. Introduction. Students get the reports to prepare.
2. Light amplification in matter.
3. Laser resonator.
4. Velocity equations and dynamic characteristics of lasers.
5. Measurement of laser radiation parameters.
6. Theoretical nonlinear optics.
7. Main effects of nonlinear optics.
8. Optical parametric oscillator.
9. Nonlinear optics and modulation of laser radiation.

10. Light propagation in crystals.
11. Optics of femtosecond laser pulses.
12. Light pressure and optical manipulation.
13. Generation of terahertz radiation.
14. Generation of non-diffracting (Bessel) light beams.
15. Promising applications of lasers and nonlinear optics devices.
16. Conclusion.

Individual homework

The order of giving, fulfilment and evaluation of individual homework is determined by the method of current control.

The purpose of the individual homework is to broaden students' horizons in those areas of laser physics and nonlinear optics that were not covered in the seminars or were covered to a limited extent, and for students to write an abstract on one of the proposed topics.

The content of the individual homework: students are offered a wide choice of topics (in addition to the proposed topics students can choose any other topic (for example, related to their research work in the laboratory) in agreement with the teacher), within the framework of which it is supposed to conduct a search of scientific literature (periodical scientific publications, conference proceedings, Internet resources), writing a literature review and presentation of the obtained information to the group in the form of a scientific report (30-40 minutes) with subsequent joint discussion.

Examples of topics for individual homework:

1. «Neodymium lasers with nonlinear optical frequency conversion».
2. «Laser and fiber gyros».
3. «Nonlinear optical converters PPLN based».
4. «Quantum-dimensional lasers for fiber-optic communication lines».
5. «DFB fiber lasers».
6. «Generation of short optical pulses by semiconductor lasers».
7. «Detection the short and ultrashort light pulses».
8. «Quantum-cascade lasers».
9. «Fiber and solid-state lasers with semiconductor pumping».
10. «Modern methods of generating terahertz radiation».
11. «Optical interferometers».

Reference Books:

1. “Optics, Light and Lasers, The Practical Approach to Modern Aspects of Photonics and Laser Physics”, Dieter Meschede, Wiley, 2017.
2. Physics of Nonlinear Optics”, Y. V. G. S. Murti, C. Vijayan, Springer, 2021.
3. “Nonlinear Optics”, Alan Newell, CRC Press, 2018.
4. “Springer Handbook of Lasers and Optics”, Frank Träger, Springer Berlin Heidelberg, 2012.

ELECTIVE III

24-DEC1-33032 BASIC TECHNOLOGIES FOR THE MANUFACTURE OF INTEGRATED CIRCUITS

Course Objectives: ***On completion of this course the student will be able to:***

1. Acquire knowledge of modern and advanced technological processes of manufacturing integrated circuits, as well as expanding knowledge of the features of manufacturing integrated circuits of various types and methods of parameter control.
2. Master the skills to develop a sequence of stages of technological operations in the creation of elements of integrated circuits, with subsequent evaluation of their performance.
3. Form skills to determine the parameters of integrated circuit elements that determine their functionality, analyze the obtained results and create accompanying documentation.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					3
CO2	3	3		3	3	3
CO3	3			3	3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction.	Basic concepts and definitions: integrated circuit, integrated circuit element, technological (topological) standards, manufacturing technology, technological operation, technological process. Roadmap. Clean factories.
2	Topic 1. Basic principles of CMOS technology	Integrated circuits and planar technology. MOS transistor and CMOS technology. Moore's law. Scaling process. Analysis of heat dissipation problem. Dissipation problem. Major problems of miniaturization. Clock frequency. Estimation of maximum performance. Principles of miniaturization. Compromises of miniaturization. Limitations of miniaturization. Formation of transistors in near-surface layers of silicon (FEOL - The front-end-of-line): basic concepts and development trends, transistor channel creation, transistor gate creation, FEOL process route. Formation of intercell interconnects and interlevel wiring (BEOL - Back end of line): basic concepts and development trends, creation of interlevel dielectric, creation of interlevel wiring, technological route BEOL.
3	Topic 2. Special technological methods for manufacturing integrated circuits	Classification of methods of manufacturing integrated circuits. The main stages of the technological route. Requirements for technological processes: reliability, economy, safety, high accuracy, high purity of materials and premises. Basic materials of integrated electronics products. General methods of forming bipolar and TIR structures. Diffusion. Implantation.
4	Topic 3. Technological route	Selection of technological process in the design of integrated circuit. Existing technologies of modern integrated circuits manufacturing. Modification of technological process. Technology with self-coupled polysilicon gate. Technologies with metal gate. Bulk technologies.

5	Topic 4. Dielectric structural layers	Dielectric layers of multilevel metallization. Functional purpose of layers. Methods of formation of dielectric layers. Formation of thin layers by methods of chemical vapor deposition. Formation of thin layers by low-temperature plasma chemical vapor deposition. Atomic Layer Deposition (ALD). Planarization process of dielectric layers. Chemical-mechanical planarization. Chemical and mechanical planarization equipment. Chemical and mechanical planarization technology.
6	Topic 5. Methods of on-chip element isolation	Methods of intercell isolation. Insulation technology: reverse shifted pn-junction, local silicon oxidation, small trench insulation (STI). Complete dielectric isolation of elements. Process of obtaining initial wafers and creation of active components.
7	Topic 6. Element switching	Metallization of ultra-large integrated circuits. Development of integrated circuits metallization system. Methods of metal films formation: electron beam evaporation, ion sputtering, cathode sputtering, magnetron sputtering. Classification of elements of integrated circuits metallization system. Single-layer metallization on the basis of aluminum. Aluminum-based multilayer metallization system. Classification of metallization layers. Principle of creation of diffusion-barrier layers. Degradation process of thin layers. Criteria of diffusion barrier layer material selection. Ohmic contacts. Requirements to ohmic contacts in the integrated circuit structure. Formation of silicide contacts. Properties of silicide and methods of their synthesis. Interaction of silicides with silicon. Salicide technology. Problems of contact layers formation. Silicon oxide growth on silicide surface.
8	Topic 7. Copper-based metallization system	Copper-based multilayer metallization technology. Formation of copper metallization by direct photolithography and dry etching. The "damascene" technology. Technologies for filling narrow trenches and contact wells with copper.
9	Topic 8. Methods of forming the pattern of integrated circuits	Features of lithography processes. Features of the composition of photoresists. Mask. Photolithography. Shapes of alignment. Resolution capacity. Features of submicron lithography. Basic concepts and trends. CUF immersion lithography. ELF lithography. Imprinting. Electron lithography. Technology of electron beam lithography. Ion lithography. X-ray lithography.
10	Topic 9. Features of submicron transistor technology	Design of typical submicron transistors. LDD - MOS transistor. Stressed silicon technology. Transistors of silicon-on-insulator technology Partially depleted CED MOSFETs. Fully depleted CED MOSFETs. Ultra-thin CED MOSFETs. Comparison of fully and partially depleted CED MOSFETs. Scaling of CED MOSFETs. Short-channel effects. Narrow channel effects. Film thickness. Multigate MOSFET technologies. Double-gate CED MOSFETs. Three-gate CED MOSFETs. CED MOSFETs with surrounding gate (four-gate). Other multigate MOSFET structures. FinFET technology. 3D integration. Vertical structures. Ring-gate transistors.

11	Topic 10. Analyzing the development of silicon technology	Fundamental thickness limits of structure-forming films for digital integrated circuits. Energy. Fast performance. Heat dissipation. Ways to improve and overcome limitations. Materials and substrates for submicron and deep-submicron VLSI. Advantages and disadvantages of silicon technologies for submicron VLSI production. Features of silicon dioxide films. Alternative dielectrics. Dielectric selection for interlayer isolation. Dielectrics with high and low dielectric constant.
12	Topic 11. Indicators of quality and reliability of integrated circuits	Design and technological features of ICs, affecting their reliability. Control system of technological process. Quality control after films production. Technological factors affecting reliability. Diagnostics of operational violations and quality assessment of integrated circuits manufacturing for compliance with the standards.
13	Topic 12. Technological processes of integrated circuits assembly	Separation of wafers into crystals. Mounting of crystals in cases with eutectic solders and adhesives. Mounting of crystals in enclosures with fusible solders. Automated assembly of crystals in cases by vibration soldering. Quality control of assembly operations. Sealing of integrated circuits. Sealing of enclosures by welding. Sealing of enclosures by soldering. Sealing with plastics. Non-casing sealing. Control of hermetic tightness of products. Main reasons of decrease of moisture resistance of devices.
14	Conclusion. Trends in the development of integrated circuit technology	New technologies and directions in the production of integrated circuits. Forecast of modification of existing technologies. Prospects of creation of alternative devices. Semiconductor compound silicon - germanium. Bipolar SiGe transistor. BiCMOS technology based on SiGe. Silicon carbide. Elements based on silicon carbide. Power devices. Production of microwave devices. Prospects of SiC technology development.

List of practice works

Name	Ac/h
1. Structure and elements of an integrated circuit.	2
2. Calculation of dielectric properties of structural materials.	2
3. Calculating the parameters of metallic interconnections.	2
4. CMOS chip scaling. Calculation of the limiting value of silicon electronics.	2
5. Peculiarities of technology for creating metal compounds from aluminum and copper.	2
6. Structures with a vertical channel and with a vertical gate.	2
7. Methods of quality control of structural layers of integrated circuits.	2
8. Quality indicators of silicon technology.	3
Total	17

Reference Books:

1. "Fundamentals of Layout Design for Electronic Circuits", Jens Lienig, Juergen Scheible, Springer, 2020.
2. "Electronic Design Automation for IC Implementation, Circuit Design, and Process Technology", Grant Martin, Igor L. Markov, Louis K. Scheffer, Luciano Lavagno, CRC Press, 2017.

ELECTIVE-IV

24-DEC1-33041 LASER FUNDAMENTALS

Course Objectives: ***On completion of this course the student will be able to:***

1. Learn principles of creation of inverse population of energy levels.
2. Study dynamics of processes of radiation fields formation in laser resonators.
3. Form skills of numerical modelling of travelling wave amplifiers in stationary and pulse modes, as well as nonlinear optical barriers and switches.
4. Work with literature, use numerical modelling methods in solving physical problems.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3				3	1
CO2	3				3	1
CO3	3				3	3
CO4	3	3		3	2	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Saturation effects. Optical quantum amplifiers	Absorption saturation. Stationary and pulse modes. Gain saturation. Stationary and pulse modes. Travelling Wave Amplifier in stationary and pulse modes.
2	Passive optical resonators	Passive resonators, resonator modes, stable and unstable resonators. Main types of resonators.
3	Methods of laser pumping. Modes of laser operation. Main types of lasers.	Optical and electric laser pumping. Continuous mode of operation. Non-stationary mode of operation (free generation mode, Q-switching, mode synchronization). Basic types of lasers.
4	Generation of optical radiation harmonics	Polarization of dielectrics. Effects of excitation of second harmonic oscillations and detection of light wave. Coherence length. Phase synchronism in birefringent crystals during harmonic generation.
5	Non-linear optical limiters and switches	Physical processes used to create non-linear optical limiters and switches. Non-linear optical limiters based on reverse saturable absorption and photoinduced scattering. Possibility of creating ultrafast switches of laser radiation based on polarization non-linearity.
6	Non-linear laser spectroscopy	Excited state spectroscopy (total conversion method, energy transfer method). Ultrahigh resolution spectroscopy (two-photon resonance method, monrochromatization velocity method).
7	Some laser applications	Laser chemistry, laser isotope separation

List of laboratory works

Name	Ac/h
1. Modelling of a travelling wave amplifier in steady-state mode	4
2. Modelling of a travelling wave amplifier in a pulsed mode	4
3. Modelling of the field in plane-parallel and confocal resonators	3
4. Study of the effect of inverse saturable absorption	3
5. Modelling of a fast-acting switch of optical radiation	3
Total	**17**

List of practical classes

Name	Ac/h
1. Numerical simulation of an optical quantum amplifier in continuous and pulse modes	4
2. Numerical simulation of plane-parallel and confocal resonators.	4
3. Methods of laser pumping. Modes of lasers operation. Basic types of lasers.	3
4. Numerical simulation of a non-linear optical limiter and switch	3
5. Numerical simulation of a non-linear optical switch laser radiation	3
Total	**34**

Report

Topics:

1. Q-switching mode.
2. Mode Synchronization
3. Solid state lasers.
4. Gas lasers.
5. Dye lasers.
6. Semiconductor lasers
7. Excimer lasers.
8. X-ray lasers.

Reference Books:

1. "Nanostructured Nonlinear Optical Materials Formation and Characterization", Rashid A. Ganeev, Elsevier Science, 2018.
2. "Laser-Matter Interaction for Radiation and Energy", Hitendra K. Malik, CRC Press, 2021.

ELECTIVE-IV

24-DEC1-33042 ELECTRONICS AND RADIOPHOTONICS

MATERIALS DIAGNOSTICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Acquire knowledge about the physical basis of diagnostic methods of materials and elements of electronics and radiophotonics and the development of skills in scientific research and development, as well as mastering new methodological approaches to solving problems in the professional field of activity.
2. Form the skills to understand the experimental equipment used for diagnostics of materials and elements of solid-state electronics and radiophotonics, to determine the expediency and sequence of application of diagnostic procedures for research of nature and properties of specific materials and elements of microelectronics and radiophotonics.
3. Use actual methods of diagnostics of materials and elements of modern electronics and radiophotonics, based on the use of complex principles of realisation of technological and diagnostic tasks in a single cycle.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3		3	3	3
CO2	3				3	3
CO3	3	3		2	3	1

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	Structure and brief content of the discipline, objectives of separate sections of the course, connection with other disciplines of the academic course.
2	Basic concepts of crystallography. X-ray structural microanalysis.	Crystal lattice, lattice constant, translational symmetry. Bravais lattice, crystalline systems and families (syngonies). Interplanar distances, Miller indices. Inverse lattice and principles of its construction, inverse lattice vector, unit cell volume. The Wolf-Bragg condition. Laue method. Powder method. Calculation of diffractograms of X-ray microanalysis.
3	Basic concepts of scattering theory.	Elastic scattering of particles. Target parameter and scattering selenium. Bohr and Thomas-Fermi interaction potentials. Quantum mechanical approach to the description of elastic scattering processes. Inelastic scattering. Bethe-Bloch formula for excitation of intraatomic transitions. Ionisation cross section. Energy losses in inelastic scattering. Photon scattering. Absorption of light by free charge carriers. Fundamental or basic absorption of light. Impurity and lattice absorption of electromagnetic energy. Phonon spectrum.

4	Physical processes occurring during interaction of ion flows with condensed medium.	Total and differential scattering cross sections. Diversity (classification) of physical processes occurring in the interaction of an ion beam with a solid target. Stopping ability of ions and specific energy losses. Basic provisions of the Linchard-Sharf-Shiott theory. Electron and nuclear stopping power. The notion of an accelerated particle's travelling distance in a solid body. Energy regions distinguished by the basic physical mechanism of ion stopping: The notion of straggling as a physical limit to the accuracy of determining the scattering coordinate of an accelerated ion. Sigmund's physical model of ion sputtering. Cascade of displacements initiated by accelerated ion and threshold sputtering energy. Sputtering coefficient. Calculation of sputtering coefficient and approximation relationships. Ion introduction, distribution of introduced impurity.
5	Rutherford backscattering.	E. Rutherford's experiments to study the structure of the atom. Physical bases of Rutherford backscattering (RBS). Kinematic factor. Energy losses of backscattered ion. Determination of film thickness and interface positions in layered structures. Determination of composite target composition. Experimental equipment for measuring RBS spectra. Registration detectors and energy resolution. Designs of semiconductor detectors and electrostatic analysers. Areas of possible and effective use of detectors and analysers. Mass resolution. Depth resolution. Energy Struggling. Sliding Angle Method. Practical examples of the study of implanted ion spectra. Determination of chemical interaction in the analysis of layered structures. Medium and low energy ion scattering methods. Ion calibration. Critical angle of axial channeling. Minimum yield of channeled ions. Diagnostics of structural ordering of crystal objects.
6	Secondary ion and atomic mass spectrometry (SIMS and SAMS).	Physical basis of secondary atomic and ionic atomic spectrometry methods. Mass spectrometric analysis of neutral atomised particles. SAMS. Equipment for SIMS analysis. Requirements for the primary ion beam. Facilities for obtaining information on the surface distribution of an element with a scanning ion probe. Sensitivity threshold. Factors determining the resolving power. Trace element analysis. Ion imaging. Quantitative analysis by SIMS. Depth profiles of elemental concentrations. Instrumental factors affecting depth resolution in measuring concentration profiles. Influence of ion matrix effects on the depth resolution of concentration profile measurements. Inner interface broadening. Ion mixing. Surface investigation. Depth concentration profiles. Particle distribution on the surface, microanalysis and volumetric analysis.
7	Interaction of an electron beam with a condensed medium.	Sources of electron beams. Thermoelectronic and auto-electronic emission. Energy of electron flow. Trajectory of electron motion in electric and magnetic fields. Controlling and accelerating systems. Basic physical processes of interaction of electrons with condensed medium. Energy losses of an electron during propagation in a solid body. Bethe formula.

8	Electron microscopy and X-ray microanalysis.	Scanning electron microscopy (SEM). Factors determining the resolution of SEM. SEM for registration of surface potentials and magnetic fields. Low-temperature electron microscopy of potentials distributions in surface structures. The method of registration of Electron-beam-induced current (EBIC). Investigation of critical temperature distribution in superconductor topological structures. X-ray spectral studies of the composition of solid objects. Scanning electron microscope microanalyser (SEMMA). Scheme, construction and operational characteristics of SEMMA. Crystal diffraction and semiconductor spectrometers for microprobe studies. Interpretation of the results of X-ray spectral measurements. Quantitative microanalysis (QMSMA). Scanning transmission electron microscope (STEM). Preparation of samples for STEM. Method of electron beams diffraction and film structure diagnostics. Equipment for electron analysis.
9	X-ray photoelectron spectroscopy.	X-ray absorption. Qualitative and quantitative analysis with the use of X-ray photoelectron spectroscopy (XPS) (Electron Spectroscopy for Chemical Analysis ESCA). Possibility to obtain information on the structure and chemical properties of inorganic compounds. Scheme of the method and design of diagnostic equipment. X-ray sources and energy analysers. Requirements for samples. Obtaining concentration profiles by depth with the use of ion etching. Crater and surface charging effects. Charge compensation. XPS at a sliding angle.
10	Auger electron spectroscopy.	Depth of Auger electron yield. Probabilities of ionisation of internal levels by electron impact. Scattering cross section of Auger process at electron impact. Experimental equipment of Auger electron spectroscopy (AES). Differentiation, analysis and modelling of Auger spectra. Elemental and quantitative Auger analysis. Factors determining the resolving power and sensitivity of AES. Application of ion etching to study element distribution profiles. Comparative analysis of diagnostic capabilities and analitical characteristics of AES and SIMS methods.
11	Tunnelling and atomic force microscopy.	Physical prerequisites for the application of the phenomenon of electrons tunnelling through energy barriers for the purposes of analytical diagnostics of condensed matter surfaces. Studies of the Josephson tunnelling effect in superconductors. Differrentiation of tunnelling contacts current–voltage characteristic. Influence of physical characteristics of contact electrodes on the tunnelling transition current–voltage characteristic. Emergence of tunnelling microscopy. Design of a scanning tunnelling microscope (STM). Obtaining and analysing three-dimensional images using STM. Requirements to samples for STM. Physical bases of atomic force microscopy (AFM). Main differences between STM and AFM. Atomic reconstruction of sample surface by means of probes for AFM.

12	Ellipsometry	Plane electromagnetic wave, its propagation in a medium. Reflection of a plane electromagnetic wave from the surface under study, Fresnel equations. Basic equation of ellipsometry. Direct and inverse problems. Homogeneous semi-infinite medium. Single-layer model. Multilayer model and optically inhomogeneous layer. Composite media. Methods of measuring ellipsometric parameters. Optical schemes of ellipsometers.
13	Conclusion	Main directions of methods development for diagnostics of electronics materials.

List of laboratory works

Name	Ac/h
1. Learning the basics of X-ray microanalysis: the Wolf-Bragg diffraction.	2
2. Rutherford backscattering: study of single-component films.	2
3. Rutherford backscattering: the study of multicomponent films.	3
4. Medium energy ion scattering method: determination of stoichiometric composition.	2
5. Ellipsometry: determination of thickness and refractive index of a homogeneous semi-infinite medium.	2
6. Ellipsometry: single layer model.	2
7. Ellipsometry: a multilayer model.	4
Total	17

List of practical classes

Name	Ac/h
1. Basic concepts of crystallography.	2
2. Basics of X-ray microanalysis.	2
3. Basic concepts of scattering theory.	2
4. Basic concepts of atomic particle scattering cross sections.	4
5. Physical processes occurring during interaction of ion flows with condensed medium.	4
6. Rutherford backscattering.	5
7. Secondary ion and atomic mass spectrometry.	2
8. Electron microscopy and X-ray microanalysis.	2
9. X-ray photoelectron spectroscopy.	2
10. Auger electron spectroscopy.	3
11. Tunnelling and atomic force microscopy.	3
12. Ellipsometry	3
Total	34

Reference Books:

1. “Metal Oxide Nanocomposite Thin Films for Optoelectronic Device Applications”, Rayees Ahmad Zargar, Wiley, 2023.

2. “Quantitative Core Level Photoelectron Spectroscopy”, Juan A Colón Santana, Morgan & Claypool Publishers, 2016.
3. “Modern ESCAThe Principles and Practice of X-Ray Photoelectron Spectroscopy”, Tery L. Barr, CRC Press, 2020
4. “The Physics and Fabrication of Microstructures and Microdevices”, Claude Weisbuch, Michael J. Kelly, Springer Berlin Heidelberg, 2012.
5. “Surface Analysis, The Principal Techniques”, Ian S. Gilmore, John C. Vickerman, Wiley, 2011.

ELECTIVE-V

24-DEC1-33051 CARBON NANOELECTRONICS

Course Objectives: ***On completion of this course the student will be able to:***

1. Study the basic properties of carbon materials, the resulting applications of these carbon materials in electronics, electro-optics and optoelectronics.
2. Understand specificity of carbon materials, skills of searching ways of their application, as well as possible analogues and directions of development among other materials of electronics closely related to carbon materials. e.g. dichalcogenides and topological insulators.
3. Master the basics of design of devices based on carbon materials, their analogues and various combined variants.
4. Develop qualitative reasoning skills in order to be able to predict the properties of a given material without or with minimal use of complex mathematical apparatus.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3				3	1
CO2	3				3	1
CO3	3				3	2
CO4	3			3	2	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Topic 1. Carbon materials characteristics and diversity of their forms.	Some of the most relevant applications of carbon materials. The idea of all-carbon electronics. General ideas about the possibility of classification of carbon materials. Carbon materials with ordered distribution of hybridised chemical bonds, amorphous and pseudoamorphous carbon materials. The concepts of allotropy and polytypism, their specificity and the need for clarification in the case of carbon. Synthesis of carbines, their chemical properties and potential applications in electronics. Diamond-like hydrogenated forms - adamantane, cubane, diamandiodes. Their applications in medicine, catalysis and organic electronics. Graphene foams and their possible applications. NDC material (nanodiamond composite).
2	Topic 2. Quantum chemical basis for modelling the geometrical and electronic structure of carbon-containing molecules.	Hartree-Fock method, Debye-Hückel method. Semi-empirical methods of quantum chemistry, density functional method and their most common implementations in application software packages.
3	Topic 3. Crystalline lattice materials based on mono- and polycrystalline diamond.	Physical and electronic properties of diamond. Methods of diamond synthesis. Delta layers as a necessary element of diamond transistor electronics. Specificity of transistor structures of MISFET, MESFET, ISFET type based on diamond. Problems of diamond electronics. CVD-diamonds and detonation synthesis diamonds. 3D structures based on diamond. Combined graphene-diamond structures.

4	Topic 4. Silicon carbide SiC is an example of the polytypism of crystalline carbon materials.	Silicon carbide-based power electronics devices. Problems of carbide technology and electronics.
5	Topic 5. Graphene is the basic 2D material of carbon electronics.	Physical and electronic properties. Main applications of graphene in nanoelectronics. Transistors, optoelectronics, metamaterials, emission electronics, plasmonics, nano-electromechanics. Methods of graphene synthesis. Combinations of graphene and diamond electronics. Methods of graphene synthesis - CVD, silicon carbide sublimation, graphene-oxide GO reduction.
6	Topic 6. Fullerenes and their derivatives in nanoelectronics.	Fullerenes as the first step into the world of diverse allotropic forms of carbon. Physical and electronic properties of fullerenes. Methods of fullerenes synthesis. Cluster series of fullerenes with magic numbers. Assembly models of fullerenes. Synthesis from polyring clusters, the Maracuma puzzle. The conjugation effect in organic molecules and its manifestation in fullerene-like clusters. Application of fullerenes in electro-optics and optoelectronics (solar cells). Fullerites. Fullerenols and their application in NEMS.
7	Topic 7. Carbon nanotubes in nanoelectronics.	Potential applications of nanotubes in electronics. Transistors, emission electronics, nanotube-based NEMS. Electronic properties of functionalised nanotubes and their chemical applications. Fullerene-nanotube, graphene-nanotube based combination systems. Non-carbon nanotubes.
8	Topic 8. Materials related to layered carbon materials.	Topological insulators as potential complementary materials for carbon electronics. Aaronov-Bohm effect and topological phase. The notion of topologically protected invariants. The spin Hall effect. 2D and 3D─ topological insulators. TI in Möbius ribbons and quantum rings. Dichalcogenides, their modelling and defects. Basic electronic properties. Applications in microelectronics and other fields. Devices on the hybrid basis MX2 - graphene. Borofen.
9	Topic 9. Analogues of biological nanostructures as a basis for future biomolecular circuitry.	Concept of conjugated hydrogen ion-hydrogen ion bonding systems. Simple and resonant groups in biopolymers. Bionic nanostructures as possible circuit elements. Molecular membranes and chemosensors.

List of practical classes

№	Name	Ac.h.
	Practical analysis of existing and hypothetical nanocarbon materials	2
1	Construction of structures of fullerenes and endofullerenes optimised using molecular mechanics semi-empirical quantum chemistry methods (SEQCM - semi-empirical quantum chemistry methods) and DFT. Estimation and calculation of electronic properties. Ab initio and semi-empirical quantum chemistry methods on the simplest objects	6
2	Practice of solving problems on calculation of electronic properties of graphenes, graphene nanoribbons, periodic graphene structures using the method of Green's functions.	4

3	Construction of bulk structures of carbon nanotubes of different chirality optimised using MM and SEQCM methods. Determination and evaluation of their electronic and optical properties.	3
4	Construction of volume structures of different SiC polytypes optimised using MM and SEQCM methods	3
5	Comparison of the operation and performance of diamond and silicon carbide electronic devices with that of classical silicon elements	4
6	Structure construction of various MX2 dichalcogenides and their combined structures with graphenes optimised using MM and SEQCM methods	4
7	Construction of carbines and various fulleroid structures (shungite nanoconus barrels etc.) optimised using MM and SEQCM methods. Evaluation of their thermodynamic properties	4
8	Construction of real and speculative bionic objects as potential circuit elements	8
	Total	**36**

Reference Books:

1. "Nanotechnology for Electronic Applications (Materials Horizons: From Nature to Nanomaterials)",NabisabMujawar Mubarak, Sreerag Gopi, Preetha Balakrishnan, springer,2022, ISBN 978 9811660214
2. "Two-Dimensional Carbon Fundamental Properties, Synthesis, Characterization, and Applications", Shen Zexiang, Wu Yihong, Yu Ting, Pan Stanford, 2014.
3. "Advanced Materials Science and Engineering of Carbon", Michio Inagaki, Feiyu Kang, Masahiro Toyoda, Hidetaka Konno, Elsevier Science, 2013.
4. "Emerging Carbon Materials for Catalysis", Samahe Sadjadi, Elsevier Science, 2020.
5. Low-dimensional Materials and Applications, Ying Jia, Guogen Xu, Xuanjun Wang, National Defense Industry Press, 2017.

ELECTIVE V

24-DEC1-33052 PHOTONICS MATERIALS

Course Objectives: ***On completion of this course the student will be able to:***

1. Form basic and practical skills for the correct use of material and science patterns to realize the potential capabilities of materials in the design and creation of micro and nano systems for nanoelectronics, photonics, micro and nanosystem technology, nanosensory;
2. Use the mathematical apparatus of percolation theory and fractal physics.
3. Acquire knowledge and understanding of physics and chemistry of processes and phenomena occurring in photonics materials.
4. Choose and apply in practice methods of experimental evaluation of the physical properties of solar energy materials at various scaling levels.
5. Acquire practical skills for the correct use of material-science patterns in the design and creation of micro and nanosystems for nanoelectronics, photonics, micro and nanosystem technology, nanosensory.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2		3	3	3
CO2	3			3	3	1
CO3	3				3	1
CO4	3	2		2	3	1
CO5	3			2	3	3

1- slightly, 2- moderately, 3-substantially

Contents

No.	Name	Content
1	Introduction	Course structure, basic concepts and definitions
2	A systematic approach to materials science	Classification of materials by technical purpose and functional properties: structural, functionally active, adaptive materials wires, conductors, semiconductors, superconductors, dielectrics. A systematic approach to the materials science of microsystems. Structural hierarchy of materials. Atoms, molecules, associates, clusters, clathrates, supramolecular formations, aggregates, nanoparticles, organized layers, nanocomposites, composite nanostructures, nanostructured materials, solid. Dimensional effects in nano-objects and fundamentally new cooperative phenomena in nanosystems. Illustration on examples of the effects of ballistic transport, Coulomb blockade of resonant tunneling, spin-dependent tunneling, giant Raman scattering. Physic and chemical principles of materials design. Principles of assembly and self-organization.

3	Fundamentals of cluster formation and materials science of cluster systems	Small ensembles of molecules, intermolecular interactions. Dimensional and functional properties of clusters. Geometric principles of cluster formation. Model representations of stable forms and masses of clusters. Features of clusters and cluster nanosystems depending on the technological genesis (molecular, gas-phase, solid-state and colloidal clusters). Semiconductor clusters with a shell structure. Matrix isolated cluster nanosystems. Cluster crystals. Clathrates. Electrically conductive and optical properties. Nanolasers and LEDs with adjustable wavelength.
4	Semiconductor artificial nanosystems with reduced dimension	Heterostructural concept of optoelectronics materials. Properties of multicomponent solid solutions. Semiconductor artificial carriers with reduced dimension. Structures with quantum wells, multiple quantum wells, composite, doped and combined super grids, quantum wires, quantum dots. Nanosystems based on quantum-dimensional elements. Nano optoelectronics devices. Nanoelectronics on heterostructural nanowires.
5	Fractal models and elements of percolation theory in materials science	Basic concepts of fractal theory. Geometric, algebraic and stochastic fractals. Physical fractals. The nature and physic and chemical features of the formation of fractal clusters. Fractal nano-objects obtained in various nanotechnological processes. Features of fractal nano-objects obtained in sol-gel technologies, in plasma chemical, reactive ion plasma and other processes. Formation of percolation fractal clusters in nanocomposites. The main elements of percolation theory. Invariants of percolation theory. The level of leakage. Universal critical indexes. Fractal dimension of the percolation cluster near the flow threshold. Percolation networks and the evolution of fractal clusters.
6	Properties of isolated nanoparticles and nanocrystalline materials	The fundamental difference between nanocrystalline systems and polycrystals. Properties of isolated crystalline nanoparticles and nanocrystalline materials. Changes in melting temperature, catalytic activity, crystal lattice period, phonon spectrum and heat capacity, magnetic and optical properties depending on size, structural and phase transformations. Development of nanoreactor materials science for obtaining nanosystems with a given dimension. Nanoreactors: nanotubes, mesoporous matrices, double layered hydroxides and clays, zeolites, opals, varieties of template threshold synthesis. Examples of the formation of nanoreactors based on highly organized mesoporous silicon oxide (MSM41). Models of the structure of nanosystems based on crystalline nanoparticles (gas-like model and model of non-equilibrium interfaces). Anomalies of mechanical, thermal, electrical and magnetic properties of nanocrystalline systems. Prospects of application in micro and nanosystem technology.
7	Materials science of fullerenes and fullerene-like materials.	The history of the discovery of fullerenes as a new molecular form of the organization of carbon atoms. The structure of fullerenes. The isolated pentagon rule. Theoretical derivation of the stability of fullerene forms. Basic physical and chemical properties of fullerenes.

		Polymer structures based on fullerenes. Nanosystems based on intercalated fullerides. The effect of superconductivity. Exo and endohedral derivatives of fullerenes. Nanosystems of superdense recording of information on endohedral derivatives. Nanosystems based on exogenous fullerenes for emission nanoelectronics. Bulbous nanostructures based on fullerenes. Schlegel diagram. Metallocarbohedryne (M8C12). Materials science of fullerenes and fullerene-like materials. Fullerenes and fullerene-like materials as components of composite nanosystems for soft nanolithography, nano-ink, template synthesis of porous materials in photochemistry and nano-photonics.
8	Nanotubes and tubular nanosystems.	Classical ideas about amorphous materials. Long-term relaxation processes. Photo memory. Metal-dielectric junctions. The phenomenon of transfer under conditions of hopping conductivity. Physical models explaining the features of electronic and optical properties of disordered micro and nanosystems. Mobility gap. Models with positive and negative correlation energy. Models based on atomic terms and modification of chemical bond lengths. Configuration diagram. Models of variable valence. A model of two electronic centers. Models of three-center connections. Materials science concepts of multilevel modification of properties of amorphous micro and nanosystems (near environment, middle environment, topology, reconstruction of the defect system). Structural phase transitions. Properties of disordered micro and nanosystems. Technical devices with superdense optical recording of information based on materials with a structural phase transition in nano-areas.
9	Materials science of porous micro and nanosystems.	Polymers. Polymer chains. Branched polymers. Block copolymers. Dendrons and dendrimers. Partially crystalline, glassy, highly elastic and viscous state of polymers. Changes in the structure of solutions of amphiphilic molecules with an increase in their concentration. Micelles. Liposomes. Percolation model of polymer structure. Persistent length. The tangle –globule transition. The theory of reptation. Polymers for the functionalization of surfaces. Examples of assembling nanoparticles into organized layers on functionalized surfaces. Adsorption – neutralization cycles for the formation of highly organized (ordered) monolayers. The concept of nanosystem architecture. Polymer-bonded, surface-bonded, electrostatically bonded architectures. Self-organization under the action of Vandervaals forces. Materials science features of the use of polymer materials for the formation of micro and nanosystems by nanoimprinting methods. Methods of nanostamp (stamp with embossed relief), nanoprinting.
10	Conclusion	Trends in the development of photonics materials

List of practical classes

Name	Ac/h
1. Terminology, concepts of Photoelasticity	4
2. Acoustic and optics	6

3. Thermal optics	6
4. Photorefraction effect	6
5. The effect of laser radiation on materials	6
6. New nonlinear nanostructured media	6
Total	34

Report

The purpose of preparing the report is to gain in-depth knowledge on the topic related to the study of the properties of photonics materials and their practical application.

The topic is chosen by the student taking into account the topics of the future final qualifying work and is agreed with the professor.

The report should reflect the current state of the scientific and technical problem, it is mandatory to use at least 5 sources (at least half of scientific articles in highly rated journals are not older than 5 years, preferably review). The duration of the report is not less than 15 and not more than 30 minutes, mandatory preparation of the presentation (at least 10 slides).
Sample topics of reports:

1) Electro-optical effects in materials when electric fields are applied;
2) Acoustic waves and light deflectors;
3) Fiberoptic devices and their application in telecommunications;
4) Laws of Malus, Snell, Bragg
5) Veselago effect and its application in modern metamaterials
6) The use of nano- and bio-structured materials in systems for limiting optical radiation
7) The use of nano- and bio-structured materials in systems for absorbing gases and impurities
8) Use of nano- and bio-structured materials in solar energy
9) Use of nano- and bio-structured materials in biomedicine

Reference Books:

1. “Photonics and Photoactive Materials: 16 (Materials Research Proceedings)”,Paolo Prosposito, 2020, Materials Research Forum LLC
2. “Nanocomposite Materials Synthesis, Properties and Applications”, Jyotish kumar Parameswaranpillai, Nishar Hameed, Thomas Kurian, Yingfeng Yu, CRC Press, 2016.
3. “Introduction to Percolation Theory”, Dietrich Stauffer, Ammon Aharony, CRC Press, 2018.
4. “Schrödinger Theory of Electrons: Complementary Perspectives, Viraht Sahni, Springer, 2022.
5. “Sustainable Nanosystems Development, Properties, and Applications”, Marius Constantin Mirica, Mihai V. Putz, IGI Global, 2016

24-DEC1-3306 INTERDISCIPLINARY PROJECT

"DESIGNING A MICROWAVE TRANSISTOR POWER AMPLIFIER"

Course Objectives: ***On completion of this course the student will be able to:***

1. Acquire the skills necessary for the development of microwave electronics devices, from the selection of materials and technological processes for its manufacture to the assembly of the prototype.
2. Obtain knowledge about the principles and technical problems of creating microwave devices of various functional purposes; the main trends in the development of microwave devices and technologies of their manufacture.
3. Form skills that allow to choose the correct element base and components in the creation of microwave devices; to make a choice of technological process of their manufacture.
4. Acquire skills of basic computer modelling and design of microwave and devices; application of methods of control of parameters of such devices; use of technological equipment.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2			3	3
CO2	3	3			3	2
CO3	3	2		2	3	3
CO4	3	2			3	3

1- slightly, 2- moderately, 3-substantially

Contents

Sl. No.	Name of the topic of the discipline	Contents
1	Microwave device design and manufacturing technology	As a result of the interdisciplinary project a device (device model, for example, in the SYNOPSYS© SENTAURUS TCAD environment) operating in the microwave range and performing a certain function (delay line, generator, amplifier, filter, etc.) should be developed, or a sequence of technological operations for the creation of a microwave device should be designed. The principle of operation of the developed device can be based on various physical phenomena, for example, a device based on spin waves in ferromagnetics, on spatial charge waves in semiconductor plasma, on the basis of superconductivity phenomenon, etc. The specific type of the device to be developed and the specific type of the device to be used can be determined. The specific type of the developed device and its basic parameters are set by the teacher. In addition, restrictions on the type of technological design can be set. The project should present the main technological operations necessary for the manufacture of the developed device.

List of practical classes

Sl. No.	Name of the topic of the discipline	Academic hours
1	Microwave device design and manufacturing technology	8
	Total	8

24-DEC1-3307 RESEARCH PROJECT PHASE I

Pre-degree practice is to broadening and deepening the knowledge and skills obtained during the entire period undergraduates are trained, of the university, and immediately precedes the training and protection of the master's thesis.

Therefore, the main task of a student during the pre-masters practice is to concentrate its efforts on refining and deepening knowledge and understanding of the most important problems and issues of the future thesis, which may consist in the systematic accumulation and understanding of the necessary information, compiling a real plan for research and development as agreed with a term thesis preparation, careful analysis of the results obtained, their proper interpretation and reflection in his thesis presentation.

Aims and objectives of the research project phase I

The aims of pre-masters practice are to expand and consolidate the professional knowledge obtained by students in the course of study and the formation of practical skills and abilities to conduct independent research, design and engineering, as well as industrial and technological activities.

The main objective of the student during the pre-masters practice is to focus his/her efforts on clarification and improvement of knowledge and correct understanding of the most important problems and issues of the future dissertation, which may consist in systematic accumulation and comprehension of the necessary information, making a plan of research, coordinated with the term of preparation of the dissertation, careful analysis of the obtained results and their correct statement in the dissertation and reflection in the presentation.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3			3	3
CO2		3			3	3
CO3		3			3	3
CO4		3			3	3

1- slightly, 2- moderately, 3-substantially

PRACTICE CONTENT

The list of topics should correspond to the main types of professional tasks: scientific research, design-and-engineering, engineering and manufacturing, and one or more professional tasks.

The subject of the thesis shall correspond to the specifics of education, be relevant, correspond to the current conditions of science, engineering and technology. The topic of the thesis is determined by the graduating department. The student may be given the right to choose the topic of the thesis, including the proposal of his/her own topic with the necessary justification of the expediency of its development. The topics of the thesis may be proposed by other departments of the University.

For the preparation of a student is assigned a supervisor from among the professors or researchers of the University. If the work is performed at the enterprise, the student is assigned a consultant from among the employees of the enterprise (the consultant from the enterprise must have a higher education of any level). The assignment and schedule are developed by the student together with the supervisor based on the analysis of the topic and the student's potential; they are signed by the student, the supervisor and consultants, if necessary, and approved by the head of the department.

The student is personally responsible for the reliability of his/her results and fulfillment of the terms of the calendar plan.

Sl. No.	Sections (stages) of practice	Types of work in practice, including independent student work	Forms of current monitoring
1	Preparatory	1. Development of individual assignment. 2. Organizational meeting to explain the aims, objectives, content and procedure of the internship. 3. Introduction to the place of practice.	Control of organizational issues, aims, objectives and content of assignments.
2	Main	1. Collection and processing of regulatory and legal, production and technological information. 2. Execution of individual assignments.	Results of individual assignment fulfillment.
3	Final	1. Compilation and execution of the report on practice. 2. Defense of the report (interim certification).	Feedback from the head of practice from the enterprise (organization). Verification of the report on practice.

FORM OF FINAL REPORTING ON PRACTICE

The document on the results of the practice of the student is a report. The student gives a brief description of the place of practice, tasks and operations that he performed during the internship.

Terms of delivery and defense of reports on practice are established in accordance with the calendar schedule of the educational process.

The report shall be technically competent, may be illustrated with sketches, schemes, tables, photographs. The report together with the collected materials can be used in the future in writing the final qualification work.

Project report can also be defended at the place of work. In this case, the student presents a report to the department with an assessment, with signature of the head of practice from the enterprise. The assessment is taken into account when defending the report at the university. The final grade is entered in the statement and the credit book by the head of practice from the university.

SEMESTER IV

24-DEC1-3401 RESEARCH PROJECT PHASE II

Aim of research project phase II

Study and enhance knowledge of key phenomena and processes on the topic of the thesis, clarification of laws and regularities that connect them; collecting, accumulation and processing of information required for the preparation of a master's thesis; systematization of scientific and technical information; selection of methods and means of solving problems on the topic of the thesis.

Formation of the plan and program of scientific research and technical developments on the topic of the thesis; improvement of skills in the development of mathematical and physical models of the phenomena, processes or objects under study, their simulation and assessment of the degree of adequacy of the results obtained.

Acquisition of skills in handling and analyzing patent information, preparation of applications for inventions and industrial designs, preparation of scientific and technical reports in accordance with the requirements of regulatory documents, compilation of reviews and preparation of publications on the results of research.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3			3	3
CO2		3			3	3
CO3		3			3	3
CO4		3			3	3

1- slightly, 2- moderately, 3-substantially

The list of topics should correspond to the main types of professional tasks: scientific research, design-and-engineering, engineering and manufacturing, and one or more professional tasks.

The subject of the thesis shall correspond to the specifics of education, be relevant, correspond to the current conditions of science, engineering and technology. The topic of the thesis is determined by the graduating department. The student may be given the right to choose the topic of the thesis, including the proposal of his/her own topic with the necessary justification of the expediency of its development. The topics of the thesis may be proposed by other departments of the University.

For the preparation of a student is assigned a supervisor from among the professors or researchers of the University. If the work is performed at the enterprise, the student is assigned a consultant from among the employees of the enterprise (the consultant from the enterprise must have a higher education of any level). The assignment and schedule are developed by the student together with the supervisor based on the analysis of the topic and the student's potential; they are signed by the student, the supervisor and consultants, if necessary, and approved by the head of the department.

The student is personally responsible for the reliability of his/her results and fulfillment of the terms of the calendar plan.

Sl. No.	Sections (stages) of practice	Types of work in practice, including independent student work	Forms of current monitoring
1	Preparatory	1. Development of individual assignment. 2. Organizational meeting to explain the aims, objectives, content and procedure of the internship.	Control of organizational issues, aims, objectives and content of assignments.

		3. Introduction to the place of practice.	
2	Main	1. Collection and processing of regulatory and legal, production and technological information. 2. Execution of individual assignments.	Results of individual assignment fulfillment.
3	Final	1. Compilation and execution of the report on practice. 2. Defense of the report (interim certification).	Feedback from the head of practice from the enterprise (organization). Verification of the report on practice.

24-3402 EXECUTION AND DEFENSE OF THE RESEARCH PROJECT (GRADUATE QUALIFYING WORK)

Aim of Execution and Defense:

A student who has no academic debts and has fully completed the curriculum or individual study plan for the relevant educational program of higher education is allowed to the final defense of project work and submit the dissertation.

At the defense of project, graduate must show a deep knowledge of the problems, independence and originality of thinking, skills of discussion, presentation and defense of his/her point of view, the ability to mobilize available knowledge in the discussion of current problems related to the topic of the research work.

The defense of the work is evaluated by the Examination committee taking into account the opinion of the supervisor and reviewer on the following parameters: the content and design of the work; the level of defense; the sequence of work of project.

Successful completion of the defense is the basis for issuing to the student a document of higher education and qualification.

Course Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3			3	3
CO2		3			3	3
CO3		3			3	3
CO4		3			3	3

1- slightly, 2- moderately, 3-substantially

Format of dissertation is detailed in Appendix -I

APPENDIX-I

GUIDELINES FOR PREPARATION OF DISSERTATION

Preamble

While utmost attention must be paid to the content of the dissertation report, which is being submitted in partial fulfilment of the requirements of the Dual Degree Masters Programme, it is imperative that a standard format be prescribed. The same format shall also be followed in preparation of the final soft copies to be submitted to the Library in future.

1. Organisation of the Dissertation

The dissertation report shall be presented in a number of chapters, starting with Introduction and ending with Summary and Conclusions. Each of the other chapters will have a precise title reflecting the contents of the chapter. A chapter can be subdivided into sections, subsections and sub-subsection so as to present the content discretely and with due emphasis. When the work comprises two or more mutually independent investigations, the dissertation report may be divided into two or more parts, each with an appropriate title. However, the numbering of chapters will be continuous right through, for example Part 1 may comprise Chapters 2 - 5, Part 2, Chapters 6 - 9.

1.1 Introduction

The title of Chapter 1 shall be Introduction. It shall justify and highlight the problem posed, define the topic and explain the aim and scope of the work presented in the dissertation report. It may also highlight the significant contributions from the investigation.

1.2 Review of Literature

This shall normally form Chapter 2 and shall present a critical appraisal of the previous work published in the literature pertaining to the topic of the investigation. The extent and emphasis of the chapter shall depend on the nature of the investigation.

1.3 Report on the present investigation

The reporting on the investigation shall be presented in one or more chapters with appropriate chapter titles. Due importance shall be given to experimental setups, procedures adopted, techniques developed, methodologies developed and adopted. While important derivations/formulae should normally be presented in the text of these chapters, extensive and long treatments, copious details and tedious information, detailed results in tabular and graphical forms may be presented in Appendices. Representative data in table and figures may, however, be included in appropriate chapters. Figures and tables should be presented immediately following their first mention in the text. Short tables and figures (say, less than half the writing area of the page) should be presented within the text, while large table and figures may be presented on separate pages. Equations should form separate lines with appropriate paragraph separation above and below the equation line, with equation numbers flushed to the right.

1.4 Results and Discussion

This shall form the penultimate chapter of the dissertation report and shall include a thorough evaluation of the investigation carried out and bring out the contributions from the study. The discussion shall logically lead to inferences and conclusions as well as scope for possible further future work.

1.5 Summary and Conclusions

This will be the final chapter of the dissertation report. A brief report of the work carried out shall form the first part of the Chapter. Conclusions derived from the logical analysis presented in the Results and Discussions Chapter shall be presented and clearly enumerated, each point stated separately. Scope for future work should be stated lucidly in the last part of the chapter.

1.6 Appendix

Detailed information, lengthy derivations, raw experimental observations etc. are to be presented in separate appendices, which shall be numbered in Roman Capitals (e.g. "Appendix IV"). Since reference can be drawn to published/unpublished literature in the appendices these should precede the "Literature Cited" section.

1.7 Literature Cited

This should follow the Appendices, if any, otherwise the Summary and Conclusions chapter. The candidates shall follow the style of citation and style of listing in one of the standard journals in the subject area consistently throughout his/her report. However, the names of all the authors along with their initials and the full title of the article/monogram/book etc. have to be given in addition to the journals/publishers, volume, number, pages(s) and year of publication. Citation from websites should include the names(s) of author(s) (including the initials), full title of the article, website reference and when last accessed. Reference to personal communications, similarly, shall include the author, title of the communication (if any) and date of receipt.

1.8 Publications by the candidate

Articles, technical notes etc. on the topic of the dissertation report published by the candidate may be separately listed after the literature cited. This may also be included in the contents. The candidates may also include reprints of his/her publications after the literature citation.

1.9 Acknowledgements

The acknowledgments by the candidate shall follow the citation of literature, signed by him/her, with date.

2. DISSERTATION FORMAT

2.1 Paper

2.1.1 Quality: The dissertation report shall be printed / photo copied on white bond paper, whiteness 95% or above, weight 70 gram or more per square meter.

2.1.2 Size: The size of the paper shall be standard A4; height 297 mm, width 210 mm.

2.1.3 Type Setting,Text Processing and Printing: The text shall be printed employing Laserjet or Inkjet printer, the text having been processed using a standard text processor. The standard font shall be Times New Roman of 12 pts with 1.5 line spacing.

2.1.4 Page Format: The Printed Sheets shall have the following written area and margins:

Top Margin 15 mm
Head Height 3 mm
Head Separation 12 mm
Bottom Margin 22 mm
Footer 3 mm
Foot Separation 10 mm
Text Height 245 mm
Text Width 160 mm
When header is not used the top margin shall be 30 mm.

Left and Right Margins

Single sided
Left Margin 30mm

Right Margin 20 mm

2.1.5 Pagination: Page numbering in the text of the report shall be Hindu Arabic numerals at the centre of the footer. But when the candidate opts for header style the page number shall appear at the right and left top corner for the odd and even number pages, respectively. Page number "1" for the first page of the Introduction chapter shall not appear in print, only the second page will bear the number "2". The subsequent chapters shall begin on a fresh page. When header style is chosen the first page of each chapter will not have the header and the page number shall be printed at the centre of the footer. Pagination for pages before the Introduction chapter shall be in lower case Roman numerals, e.g., "iv".

2.1.6 Header: When the header style is chosen, the header can have the Chapter number and Section number (e.g., Chapter 2, Section 3) on even numbered page headers and Chapter title or Section title on the odd numbered page header.

2.1.7 Paragraph format: Vertical space between paragraphs shall be about 2.5 line spacing. The first line of each paragraph should normally be indented by five characters or 12mm. A candidate may, however, choose not to indent if he/she has provided sufficient paragraph separation. A paragraph should normally comprise more than one line. A single line of a paragraph shall not be left at the top or bottom of a page (that is, no windows or orphans should be left). The word at the right end of the first line of a page or paragraph should, as far as possible, not be hyphenated.

2.2 Chapter and Section Format

2.2.1 Chapter: Each chapter shall begin on a fresh page with an additional top margin of about 75mm. Chapter number (in Hindu-Arabic) and title shall be printed at the centre of the line in 6mm font size (18pt) in bold face using both upper and lower case (all capitals or small capitals shall not be used). A vertical gap of about 25mm shall be left between the Chapter number and Chapter title lines and between chapter title line and the first paragraph.

2.2.2 Sections and Subsections: A chapter can be divided into Sections, Subsections and Sub-sub Sections so as to present different concepts separately. Sections and subsections can be numbered using decimal points, e.g. 2.2 for the second section in Chapter 2 and 2.3.4 for the fourth Subsection in third Section of Chapter 2. Chapters, Sections and Subsections shall be included in the contents with page numbers flushed to the right. Further subsections need not be numbered or included in the contents. The Section and Sub-Section titles along with their numbers in 5 and 4mm (16 and 14 pt) fonts, respectively, in bold face shall be flushed to the left (not centred) with 15 mm space above and below these lines. In further subdivisions character size of 3 and 3.5 with bold face, small caps, all caps and italics may be used for the titles flushed left or centred. These shall not feature in the contents.

2.2.3 Table / Figure Format: As far as possible, tables and figures should be presented in portrait style. Small size table and figures (less than half of writing area of a page) should be incorporated within the text, while larger ones may be presented on separate pages. Table and figures shall be numbered chapter wise.

For example, the fourth figure in chapter 5 will bear the number Figure 5.4 or Fig 5.4 Table number and title will be placed above the table while the figure number and caption will be located below the figure. Reference for Table and Figures reproduced from elsewhere shall be cited in the last and separate line in the table and figure caption, e.g. (after McGregor[12]).

3 Auxiliary Format

3.1 Binding: The evaluation copies of the dissertation report may be spiral bound or soft bound. The final hard bound copies to be submitted after the viva-voce examination will be accepted during the submission of dissertation report with the following colour specification:

Dual Degree Masters Programme Dissertation

3.2 Front Covers: The front covers shall contain the following details:

Full title of report in 6 mm 22 point's size font properly centred and positioned at the top. Full name of the candidate in 4.5 mm 15 point's size font properly centred at the middle of the page. A 40 mm dia replica of the Institute emblem followed by the name of department, name of the Institute and

the year of submission, each in a separate line and properly centred and located at the bottom of page.

3.2.1 Lettering: All lettering shall be embossed in gold.

3.2.2 Bound back: The degree, the name of the candidate and the year of submission shall also be embossed on the bound (side) in gold.

3.3 Blank Sheets: In addition to the white sheets (binding requirement) two white sheets shall be put at the beginning and the end of the report.

3.4 Title Sheet: This shall be the first printed page of the Dissertation and shall contain the submission statement: the Dissertation Report submitted in partial fulfilment of the requirements of the M.Tech Degree, the name and Roll No. of the candidate, name(s) of the Supervisor and Co-supervisor(s) (if any), Department, Institute and year of submission.

Sample copy of the 'Title Sheet' is appended (Specimen 'A').

3.5 Dedication Sheet: If the candidate so desires(s), he/she may dedicate his/her report, which statement shall follow the title page. If included, this shall form the page 1 of the auxiliary sheets but shall not have a page number.

3.6 Approval Sheet: In the absence of a dedication sheet this will form the first page and in that case shall not have a page number. Otherwise, this will bear the number two in Roman lower case "ii" at the centre of the footer. The top line shall be: Dissertation Approval for M.Tech

A sample copy of the Approval Sheet is appended (Specimen `B')

3.7 Abstract: The 500 word abstract shall highlight the important features of the dissertation report and shall correspond to the electronic version to be submitted to the Library for inclusion in the website. The Abstract in the report, however, shall have two more parts, namely, the layout of the report giving a brief chapter wise description of the work and the key words.

3.8 Contents: The contents shall follow the Abstract and shall enlist the titles of the chapters, section and subsection using decimal notation, as in the text, with corresponding page number against them, flushed to the right.

3.8.1 List of Figures and Tables: Two separate lists of Figure captions and Table titles along with their numbers and corresponding page numbers against them shall follow the Contents.

3.9 Abbreviation Notation and Nomenclature: A complete and comprehensive list of all abbreviations, notations and nomenclature including Greek alphabets with subscripts and superscripts shall be provided after the list of tables and figures. As far as possible, generally accepted symbols and notation should be used.

Auxiliary page from dedication (if any) to abbreviations shall be numbered using Roman numerals in lower case, while the text starting from the Introduction shall be in Hindu Arabic.

The first pages in the both the cases shall not bear a page number.

3.10 A Declaration of Academic Honesty and Integrity: A declaration of Academic honesty and integrity is required to be included along with every dissertation report after the approval sheet. The format of this declaration is given in Specimen 'C' attached.

****

Specimen 'A': Title Sheet

(Title)

Dissertation Submitted in partial fulfilment of the requirements
of the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE)

by

(Name of the Student)
(Roll No._____)

Project Guide(s):
_____
_____
_____
(Name of the Department / School / Division)
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Month and Year)

Specimen `B': Approval Sheet

This dissertation entitled (Title) by (Author Name) is recommended for the award of the Dual Degree Masters Programme in Electronics Engineering (NEW GENERATION OF ELECTRONIC COMPONENT BASE).

Members of the Examination Committee (Name and Signature)

_____
_____
_____
_____

Date :_____
Place :_____

Specimen `C' – Declaration

I declare that this written submission represents my ideas in my ownwords and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

_____
(Signature)

_____
(Name of the student)

_____
(Roll No.)
Date: _____

Specimen `D' – Certificate

DEPARTMENT / SCHOOL OF ----------
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

This is to certify that the dissertation work entitled " ----------" is a bonafide record of work carried out by Mr/Ms ----------(Roll No.), submitted to the Department / School of ----------, in partial fulfilment of the requirements for the award of the offered by Division of Electronics, School of Engineering, CUSAT and Saint Petersburg Electrotechnical University (LETI), Russia during the academic year ----------.

Name and Signature of the Project Guide ----------

Signature of Head of the Division / Department / School ----------

Date: