I. I. Mechnikov Odesa National University
Faculty of Mathematics, Physics and Information Technologies
Department of Physics and Astronomy

Course Syllabus

Theoretic fundamentals of nanoelectronics

Volume	4 credits, 120 hours.
Semester, year of study	2 semester, 1st year of study
Days, time, place	Wednesday, Thursday at 8.00, room 30, Pastera st, 42
Teacher(s)	Prof. Sushko M.Ya
Контактний телефон	0972500639
E-mail	mrs@onu.edu.ua
Workplace	room 31, Pastera 42 st
Consultations	Face-to-face consultations: Monday at 14.00, room 31, Pastera 42

Силабус курсу

Теоретичні основи наноелектроніки

Обсяг	4 кредити, 90 год.
Семестр, рік навчання	2, семестр, 1-й рік навчання
Дні, час, місце	Середа, Четвер, 8.00, ауд.30, Пастера 42
Викладач (-і)	Доц. Сушко М.Я.
Контактний телефон	0972500639
E-mail	mrs@onu.edu.ua
Робоче місце	Вул. Пастера 42, ауд. 31
Консультації	Очні консультації: понеділок, 14.30-17.00, вул Пастера 42, ауд. 31

COMMUNICATION

Communication with students: E-mail: mrs@onu.edu.ua; Google-Class (who has an account at **onu.edu.ua**)

COURSE SUMMARY

The purpose of teaching the academic discipline is: to train specialists who are able to understand, combine and apply in their future professional activities the ideas and methods of modern physics and electronics, which have now come to the fore as a result of the latest achievements of nanophysics and nanotechnologies.

Objectives: to form in students the following system of competencies, which includes:

knowledge, understanding, skills and abilities to interpret and quantitatively describe the features of phenomena and physical processes in intermediate structures between molecular and macroscopic compounds and to see ways to use this experience for the practical use and development of the latest nanotechnologies; the ability to solve complex specialized nanophysics problems characterized by complexity and uncertainty of conditions, to clearly and unambiguously communicate one's own knowledge, conclusions, and arguments to specialists;

Planned learning outcomes: upon completion of the course, students will

know: new ideas, concepts and methods that have become firmly rooted in physics over the past twenty years and now form the foundation of meso- and nanophysics, quantum effects, features of transport phenomena and energy conversion in nanoscale structures and devices;

be able to: apply the principles of quantum theory to the study of nanoobjects, evaluate quantum-scale and interference effects in electronic nanocircuits, find electronic thermal and magnetic characteristics of basic elements of nanoelectronics

COURSE DESCRIPTION

Forms and methods of learning

The course will be taught in the form of lectures (30 hours) and independent work (60 hours).

The following learning methods are used during classes: explanatory-illustrative method; information-receptive; reproductive method (reproduction-reproduction); problem-based presentation method; partial-search method.

During independent work, the research method is used (the student masters the literature on the specified topic).

Content of the educational discipline

Content module 1. Transport processes in nanostructures

Topic 1. Electronic and thermal flows in low-dimensional structures. Electronic transport in nanodevices. Driving forces. Ballistic and diffusion modes of conduction. Quantum dots and nanoconductors. Quantum interference effects. Quantum interference field-effect transistors. Heat release in nanocircuits. Fundamental limitations on the degree of integration and speed. Thermal conductivity, electrical conductivity and thermoelectric effects in nanoconductors. Calculation of electrical

resistance, Peltier and Seebeck coefficients, electronic thermal conductivity. Measurement of transport characteristics.

Topic 2. Carbon nanostructures. Graphene. Structure and methods of obtaining. Density of electronic states and carrier density. Carrier scattering. Phonon spectrum. Thermal conductivity of graphene. Metal and semiconductor nanotubes. Electronic structure of nanotubes. Optical transitions. Multi-walled tubes.

Topic 3. Elements of spintronics. Giant magnetoresistive effect in nanoheterostructures. The concept of spin current. Spin diffusion. Spin injection. Spin motive forces and moments of forces. Spin field interference transistor.

Recommended literature

Basic

1. Suprio Datta. Lesson from Nanoelectronics. A New Perspective on Transport, Lessons from Nanoscience: A Lecture Notes Series, Vol. 1, Lessons from Nanoscience: A Lecture Notes Series, Vol. 2, World Scientific Publishing, 2013, 2012, 492 pp.
2. Mark Lundstrom, Changwook Jeong. Near Equilibrium transport. Fundamentals and Applications, Lessons from Nanoscience: A Lecture Notes Series, Vol. 2, World Scientific Publishing, 2013, 252 pp. https://doi.org/10.1063/5.0133335
3. В.М. Адамян, В.В. Завальнюк, В.М. Адамян, В.В. Завальнюк, Теоретичні основи наноелектроніки (конспект лекцій), Одеса 2019, с. 60
4. І.О. Вакарчук. Квантова механіка, 3-тє видання, Львів: ЛНУ ім. Івана Франка, 2007, 848 стр.

Additional

1. Ashcroft, Neil W.; Mermin, N. David, Solid state physics. New York: 1976
2. J. Fang et al., Recent advances in low-dimensional semiconductor nanomaterials and their applications in high-performance photodetectors, InfoMat **2** (2019), p. 291-317

Resources

1. A resource for nanoscience and nanotechnology: http://nanohub.org
2. **http://theorphys.onu.edu.ua/uk**

EVALUATION

Current control is carried out based on the results of students' tests and the final test.

Criteria for evaluating the performance of independent work

The evaluation criteria are: completeness of the task, structure and quality of answers and additional questions from the teacher.

Criteria for evaluating control work

The evaluation criteria are the correctness and completeness of the answer to the test questions, justification of correct answers and correction of errors as a result of personal defense of the work. The number of points is determined by the sum of correct answers, taking into account the logical connections between the tasks during computer processing of the test results. The student's activity in the process of classes is also evaluated: oral questioning, independent work; solving problems.

Final semester control (test)

1 point is deducted for each subsequent minor error or contradiction;

When assessing the level of material assimilation in points, general criteria for evaluating the academic achievements of higher education applicants are used in accordance with the provisions of the ONU named after I.I. Mechnikov. The final grade is given by the sum of the points of the current and final control on the scale given below.

COURSE POLICY

Determined by the regulatory documents/Regulations in force at I.I. Mechnikov ONU (https://onu.edu.ua/uk/geninfo/official-documents).

The deadline for completing course assignments is determined by the teacher. In case of good reasons, the teacher allows the postponement of the deadline for completing assignments. Recalculation of debts - with the permission of the dean's office.

Each student must remember about academic integrity, which is ensured by the independent completion of educational assignments, tasks of current and final control, proper reference to sources of information in the case of performing creative works, compliance with the norms of the legislation on copyright and related rights, and provision of reliable information about the results of their own scientific activities.

For violation of academic integrity, students may be held academically liable in accordance with the Regulation on Academic Integrity at I.I. Mechnikov ONU. (https://onu.edu.ua/pub/bank/userfiles/files/documents/acad-dobrochesnost.pdf).

Attendance at classes for a 1st year student is mandatory, as is timely arrival at classes. Mobile devices must be blocked during study.

Scoring scheme

Current control, independent work, individual classes				Final score
Section 1	Section 2	Section 3	Individual tasks	
30	30	30	10	100

The final scores for assessing students' knowledge for the section are calculated as follows:

№	Type of work	Form of control	Maximum number of points
1	Student's classroom activity		5
2	Homework, independent work	Written solutions, written and oral answers	5
3	Total		10