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

Course Syllabus

Soft Matter Physics

Volume	4 кредити, 120 hours.
Semester, year of study	1 semester, 1st year of study
Days, time, place	Friday at 13.00, room 16, Pastera st, 42
Teacher(s)	Prof. Malomuzh M.P.
Контактний телефон	
E-mail	mnp@onu.edu.ua
Workplace	room 16, Pastera 42 st
Consultations	Face-to-face consultations: Friday at 15.00, room 16, Pastera 42

COMMUNICATION

Communication with students: E-mail mnp@onu.edu.ua; face-to-face meetings.

COURSE SUMMARY

The subject of study of the academic discipline is the basic thermodynamic and kinetic properties of water.

The study of the discipline "Physics of Soft Matter" is preceded by the sections of the course "Statistical Physics and Thermodynamics", "Methods of Mathematical Physics", "Phase Transitions and Phase Equilibria". Knowledge of the course "Physics of Soft Matter" lays the foundation for further study of professional training disciplines and disciplines of the student's choice.

The goal of the course is to train specialists who are able to analyze the properties of liquid systems similar to helium-4, which can transition to a superfluid state, such as glycerin, which can be in a normal and highly viscous state, as well as in a glassy state, such as liquid crystals, which naturally combine the properties of liquids and crystals with anisotropic molecules, such as Coulomb gas, which can be in a gaseous and liquid state, and transition from a dielectric state to a conductor state.

The goal of the discipline “Physics of Soft Matter” is to form in students the skills of qualitative and quantitative analysis of the properties of the described systems using the methods of modern physics.

The objective of the discipline is to familiarize students with the basic approaches to describing the properties of soft matter, the principles of constructing order parameters and the equation of state of matter and describing its caloric properties, static and viscoelastic behavior, static and dynamic dielectric properties, describing the dielectric-conductor phase transition and the properties of the superfluid wall of GC-4; consideration of the most important problems of Soft Matter Physics (SMP): features of phase diagrams, primarily the position of the boundaries between stable and metastable states, metastable and completely unstable states, properties of matter near the boundaries, propagation of acoustic and electromagnetic excitations, features of relaxation phenomena, behavior of shear viscosity and self-diffusion coefficients, formation of skills in constructing hydrodynamic equations for various systems, description of the frequency dependence of kinetic coefficients, establishment of their tensor nature, especially in external electric and magnetic fields, analysis of molecular light scattering spectra, etc. Development of skills in modeling complex phenomena using relatively simple examples.

Learning outcomes provide opportunities to:

Know: principles of constructing hydrodynamic equations depending on the type of its order parameter; how to determine the propagation velocity and absorption coefficient of acoustic waves depending on their frequency; how to find the scattering cross section of molecular light scattering depending on the nature of the polarization of the incident and scattered light and the scattering frequency; how to calculate the temperature of the transition of the system to a state in which its properties are determined by quantum laws; features of the phase diagram of superfluid helium-4; features of the hydrodynamics of superfluid helium; reasons for the root frequency dispersion of shear viscosity in highly viscous liquids; methods for describing the dielectric-conductor phase transition using the example of a two-dimensional Coulomb gas.

Be able to: determine the type of order parameter depending on the structure of molecules and the features of intermolecular interaction; use the laws of conservation of momentum and energy, as well as entropy production, to construct hydrodynamic equations; construct correlation functions based on the hydrodynamic theory of thermal fluctuations; calculate the interaction potentials between clusters of different orders in systems similar to two-dimensional Coulomb gas and water-alcohol solutions, construct averaged interaction potentials between molecules in such systems; find the propagation velocity of acoustic waves and their absorption in micro-inhomogeneous media, which are related to highly viscous liquids; describe the dielectric properties of micro-inhomogeneous systems in their volume and near the surface; calculate the dielectric permittivity and the coefficient of electrical

conductivity in a Coulomb gas, as well as find the regions of existence and the boundary between them, which separates the states of a dielectric and a conductor; qualitatively and quantitatively describe fluctuation phenomena in liquid crystals, Coulomb systems and highly viscous liquids.

COURSE DESCRIPTION

Forms and methods of teaching

The course will be taught in the form of lectures (20 hours) and practical classes (20 hours), organization of independent work of students (80 hours).

During teaching the discipline, verbal teaching methods, visual teaching methods are used. The main verbal teaching method is a lecture. During lectures, the following teaching methods are used: explanatory-illustrative method, or information-receptive; reproductive method (reproduction - reproduction); problem-based presentation method; partial-search, or heuristic method.

During practical classes, the following teaching methods are used: partial-search, or heuristic method.

Content of the educational discipline

Content module 1. Basic thermodynamic and kinetic properties of water. Part 1.

Topic 1. Condensed states of matter:

Liquid and solid states, features of phase diagrams of various substances, metastable and absolutely unstable states, phenomena of superfluidity and superconductivity;

Topic 2. Distribution functions as structural characteristics of condensed phases:

Single-particle and binary distribution functions, structure factors, structure factor of hard spheres;

Topic 3. Features of thermal motion of molecules in various solid and liquid phases:

Bulk longitudinal and transverse modes, surface thermal excitations, vortex excitations in superfluid helium, self-diffusion processes;

Topic 4. Dielectric-conductor transition on the example of a two-dimensional Coulomb gas:

Clusters and their interaction, dielectric permittivity, gas-liquid transition, dielectric-conductor transition;

Content module 2. Basic thermodynamic and kinetic properties of water. Part 2.

Topic 1. NLC - the simplest liquid crystal system:

Mesophases, free energy, thermal excitations, fluctuations of scalar and tensor order parameters in NLC;

Topic 2. Properties of highly viscous and glassy states:

Specific behavior of thermodynamic quantities and kinetic coefficients,

Micro-inhomogeneous structure, metastable and absolutely unstable states of matter as the basis for the formation of highly viscous and glassy states,

Topic 3. Aqueous-alcoholic solutions:

Extraordinary properties of solutions, features of the structure and thermal motion of molecules, special points;

Topic 4. Dispersed systems:

Suspensions and emulsions, stability of dispersed systems, dielectric properties of dispersed systems, kinetic processes in dispersed systems.

Topic 5. Human blood as a complex fluid system:

erythrocytes and other shaped formations in blood plasma, properties of blood plasma and its role in the body, optimal temperature for human existence.

14. Recommended literature

Basic literature

1. Маломуж М.П. Електронний курс лекцій зі с/к Фізика м'якої речовини:
2. Л.А.Булавин, В.Я.Гоцульский, Н.П.Маломуж, В.Е.Чечко. Релаксационные и равновесные свойства разбавленных водных растворов спиртов// Известия РАН (серия Химическая) - №4 (2016) 851-876.
3. L.A.Bulavin, T.V.Lokotosh, N.P.Malomuzh. Role of the collective self-
4. diffusion in water and other liquids// J.Mol.Liq. (Review) - 137 (2008) 1-24.
5. Н.П.Маломуж, К.С.Шакун. Коллективные составляющие процесса самодиффузии в жидкостях // **УФН - 191**, №2 (2021) 163 – 181. ,

   https://doi.org/10.3367/UFNr.2020.05.038759 ,

   https://doi.org/10.3367/UFNe.2020.05.038759

6. L.A.Bulavin, N. P. Malomuzh, K.S. Shakun. Current problems in the quasi-elastic incoherent neutron scattering and the collective drift of molecules // In book "Selected problems in physics of liquids", Springer – **223**, 41-72 (2019).

Additional Literature

1. V. Blazhnov, N. P. Malomuzh, S. V. Lishchuk. Temperature dependence of density, thermal expansion coefficient and shear viscosity of supercooled glycerol as a reflection of its structure// J. Chem. Phys. - 2004, v. 121, № 13, pp. 6435-6441
2. Н.П.Маломуж, Е.В.Орлов. Новая версия ячеечного метода определения вязкости взвесей// Колл.ж.– 2002, т.64, № 6, с.802 – 810.
3. Oleksii V. Khorolskyi, Nikolay P.Malomuzh. Macromolecular Sizes of Serum Albumins in its Aqueous Solutions - **AIMS Biophysics**, **7** (4), 2020, 219 - 235.

4. А.А.Гуслістий, М.П.Маломуж, А.І.Фісенко. Оптимальна температура життєвої активності людини // УФЖ – **63**,.№9 (2018) 809 – 815.

15. Resources

1. Офіційний сайт кафедри теоретичної фізики: http://theorphys.onu.edu.ua/ru/main.php.
2. Wikipedia: http://en.wikipedia.org/

ASSESSMENT

The academic discipline "Physics of Soft Matter" is assessed on a 100-point scale.

Methods of current control: Current control is carried out based on the results of the test on the topics of the content modules. The student's activity during the lessons is also assessed: oral questioning, writing independent works.

Forms and methods of final control: Final semester control - test. Consists of current control and test.

Current control consists of taking into account the student's activity during the lessons (depth of answers to questions that summarize the results of previous lectures and precede the presentation of new material at the current lecture, the ability to make the necessary estimates of orders of magnitude.

The test consists of:

1) 2 qualitative questions regarding the properties of water,

2) 2 tasks where it is necessary to estimate the order of magnitude or compare contributions of different physical nature.

One of the qualitative questions is simple, the second is significantly more difficult. The tasks are the same.

When assigning points for an answer, special attention is paid to

- completeness and clarity of the answer;
- knowledge of the meaning of words and concepts;
- the degree of perfection of the English when presenting the answers.

ОЦІНЮВАННЯ

Навчальна дисципліна «Фізика м’якої речовини» оцінюється за 100-бальною шкалою.

Методи поточного контролю: Поточний контроль здійснюється за результатами виконання контрольної роботи за тематикою змістовних модулів. Оцінюється також активність студента в процесі занять: усне опитування, написання самостійних робот.

Форми і методи підсумкового контролю: Підсумковий семестровий контроль - залік. Складається з поточного контролю та залікової контрольної роботи.

Поточний контроль складається з урахування активності студента в процесі занять (глибини відповідей на питання, що підводять підсумок

попередних лекцій і передують викладенню нового матеріалу на поточній лекції, вміння зробити необхідні оцінки порядків величин.

Контрольна робота складається:

1) з 2-х якісних питань стосовно властивостей води,
2) з 2-х задач, де треба оцінити порядок величини чи порівняти внески різної фізичної природи.

Одне з якісних питань є простим, друге – суттєво складнішим. Такі ж самі є і задачі.

При виставлені балів за відповідь особлива увага звертається на

- повноту і чіткість відповіді;

- знання смислу слів і понять;

- ступінь довершеності української мови при викладенні відповідей.

Загальна схема нарахування балів

Форма поточного контролю					
Практичні заняття	Лекції*		Разом	Екзаменаційна робота	Сума
Поточний контроль (усний)	КР_1	КР_1			
20	40	40	100	-	100

Independent work of students. The results of independent work on the preparation of theoretical material are assessed by the quality of the performance of current tests.

The results of the preparation of theoretical material for practical classes are assessed by an oral survey and by the quality of the performance of current tests.

The results of the implementation of the SRS are presented in the form of a report (7-10 min), accompanied by a presentation (5-7 slides). The evaluation criteria are: completeness of the presented material, quality of the report and presentation, answers to questions from the teacher and fellow students.

The deadlines for submitting/performing independent work tasks are determined by the teacher.

COURSE POLICY

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

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

Each student must remember about academic integrity, which is ensured by independent performance of educational tasks, 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, 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 Regulations on Academic Integrity at ONU named after I.I. Mechnikov. https://onu.edu.ua/pub/bank/userfiles/files/documents/acad-dobrochesnost.pdf.

Attendance at classes is mandatory for students, as is timely arrival at classes. Mobile devices must be blocked during classes.