«APPROVED BY»
Head oft he General Physics Department
_________________Lider A.M.
« ____» _________ 2016 г.

COURS ANNOTATION

1. Title of the discipline **«Theoretical Physics. Quantum Mechanics»**

2. Code **ДИСЦ.Б**

3. Speciality (ООП) **03.03.02 Physics**

4. Specialization Program
Physics of Condensed Matter

5. Qualification degree - **bachelor**

6. Provided by **General Physics Department**

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9. Short review:
In quantum mechanics, we study the physics of the very small: molecules, atoms, and subatomic particles. As mathematical physicists, we begin with the assumptions underlying the physical theory, turn these into mathematics, and proceed to derive our results from these mathematised assumptions. The Quantum Mechanics module describes the foundations of this theory and explores some simple applications. In this project, you will focus on the further development from this starting point into an area of application or deeper theory.
This will require you to have taken the module Mathematics, and you will pursue one theme or another from the list below in more depth. Suitable textbooks are recommended below. Possible themes of study include the following:
•atomic physics, the hydrogen atom and beyond;
•relativistic quantum mechanics and modelling electrons;
•Green's functions in quantum mechanics; and
•symmetry in quantum mechanics.

10. Contents of the module (list of main topics).
The system of basic postulates of quantum mechanics. Evolution of the state of a physical system with time. Temporal Schrödinger equation. Stationary states in the picture of Schrödinger's evolution. Dependence of the average values of physical quantities on time. Integrals of motion. Exactly solvable problems of quantum

mechanics. One-dimensional motion. One-dimensional Schrödinger equation for free motion. Free movement in three dimensions. One-dimensional motion in the field of a potential wall. Particle in the field of a rectangular potential barrier. Tunneling. Reflection and transmission coefficients. Motion of a particle in a potential well. Quantum harmonic oscillator. Birth and destruction operators. Commutation relations. The action of the creation and annihilation operators on the state vector. The operator of the number of quanta. Theory of angular momentum. Range of change of quantum numbers. Addition of two commuting angular momentum operators. Clebsch-Gordan coefficients. Movement in the field of central forces. The Laplace operator in a spherical coordinate system. The hydrogen atom. Hamiltonian of the hydrogen atom. Analysis and solution of the radial equation. Recurrence relations. The energy levels of the hydrogen atom. The Rydberg constant. General analysis of the wave functions of the hydrogen atom. Electrons in Monovalent Atoms. Spectroscopic notation for atomic terms. The Rayleigh-Schrödinger perturbation theory. Perturbation theory for degenerate levels. The secular equation. Probability of transition. Transitions under the action of adiabatic perturbation and sudden perturbation. Variational method of approximate solution of the Schrödinger equation. Spin. Identity of particles. Many-electron quantum systems. Principle of identity of particles. The formulation of the principle of identity in the language of the wave function. Permutation operator and its eigenvalues. Fermions and bosons. The Pauli principle. Properties of the wave function of a system of identical particles. One-particle and many-particle Hamiltonian, one-particle and many-particle wave functions. Slater's determinant. Adiabatic approximation in the theory of polyatomic systems. Separation of electronic and nuclear motion.

11. Course is developed for third-year students. Should be provided during the 6th semester.

12. Prior knowledge requires: Mathematics: Analysis, Differential, Integration Calculus, Linear Algebra, General Physics

13. Correspondence: Physics of Condensed Matter, Research Work.

14. Type of attestation exam

Developed by, Prof. Bekhtereva E. S.

Annotated bibliography

1. Bohm. Quantum Mechanics: Theory and Applications. Springer-Verlag, 1993. Annotations: Solidly mathematical text, with physical applications and intuitions built in.

2. R. P. Feynman. The Feynman Lectures on Physics: Quantum Mechanics. Vol. 3. Addison-Wesley, 1965. Annotations: The relevant volume from one of the classic textbook series on modern physics by an extraordinary physicist and lecturer.

3. K. Hannabuss. An Introduction to Quantum Theory. Oxford University Press, 1997. Annotations: Mathematically rigorous, modern presentation of quantum theory. Only available through interlibrary loans, or on nicely asking to borrow Dr. Walker's copy.

4. L. D. Landau and E. M. Lifschitz. Quantum Mechanics: Non-relativistic Theory. Vol. 3. Pergamon Press, 1958. Annotations: The relevant volume from one of the classic textbook series on modern physics, written by a famous Soviet collaboration.

5. P. T. Matthews. Introduction to Quantum Mechanics. McGraw-Hill, 1963. Annotations: Mathematically sound, but a little dated in its language and presentation. Deals almost exclusively with systems whose properties are unchanging with respect to time.

6. M. Rae. Quantum Mechanics. Institute of Physics, 1980. Annotations: Considerably less mathematical than the others. Suitable to get a rough grounding in conjunction with more mathematical treatments.

7. L. Schiff. Quantum Mechanics. McGraw-Hill, 1955. Annotations: Fairly mathematical treatment of quantum mechanics, but showing its age at points.

8. R. Shankar. Principles of Quantum Mechanics. Plenum Press, 1980. Annotations: A fairly easy, mathematical introductory text extends out to material covered in previous module. Available as a download from CalTech.

9. S. Weinberg. Lectures on Quantum Mechanics. Cambridge University Press, 2012. Annotations: Modern textbook providing a condensed introduction to quantum mechanics. Tougher than Hannabuss, but complementing nicely at some points. Only available through interlibrary loans.