Final exam program

on discipline **"Additional chapters of scattering theory"** for 1st course doctoral students for specialty "6D060500 – Nuclear Physics"

The proposed program for the discipline **"Additional chapters of scattering theory"** is made according to the discipline's syllabus. The program determines the requirements for the levels of mastering the academic discipline, to which the student should be capable of learning: describe acquired knowledge (specifically) and it's understanding; interpret an understanding of the overall structure of the study field and the relations between its elements (specifically); generalize new knowledge in the context of basic knowledge, interpret its contents; create educational and social interaction and cooperation in the group; explain the solution of the problem, its importance; classify criticism and to criticize; decide to work in a team; combine the role of taken course in the implementation of individual learning paths. The system of descriptor verbs must be used during the formation of competences; design active and interactive methods which are recommended to ensure deeper understanding and learning of educational material and to achieve learning outcomes of the course.

The aim of the course: learning the modern physics of atomic nuclei and quantum mechanics for systems consisting of few-particles and clusters.

At the exam, students will be asked three theoretical questions (the first two are 33 points each and the third are 34 points each).

Exam questions:

1.	Give definition and describe formulation of scattering theory in terms of representation theory	Lecture № 1
2.	Describe the type of scattering matrix	Lecture № 1
3.	Give definition of the discrete spectrum	Lecture № 2
4.	Explain the virial theorem	Lecture № 2
5.	Describe same particles	Lecture № 2
6.	Give definition of statistical physics	Lecture № 3
7.	Explain S-matrix	Lecture № 4
8.	Give definition and describe continuous spectrum	Lecture № 4
9.	Describe the scattering operator in the continuous case	Lecture № 3
10.	Explain representation theory	Lecture № 3
11.	Characterize analytic properties of the wave function	Lecture № 4
12.	Give definition of spectral theory	Lecture № 5
13.	Describe the Green's function	Lecture № 5
14.	Explain perturbation theory	Lecture № 5
15.	Characterize applications of spectral theory	Lecture № 6
16.	Describe operator algebra	Lecture № 6
17.	Give definition of the time Green's function	Lecture № 5
18.	Explain translational representation for the solution of the wave equation in free space	Lecture № 7
19.	Characterize the wave function in the semiclassical approximation	Lecture № 7
20.	Describe translational representation for the solution of the wave equation in free space	Lecture № 7
21.	Explain quantum oscillator under the influence of an external force	Lecture № 8
22.	Give definition and describe parametric excitation of a quantum oscillator	Lecture № 8
23.	Explain the scattering matrix	Lecture № 9
24.	Describe heisenberg representation	Lecture № 9
25.	Give definition of canonical transformations	Lecture № 9
26.	Describe generalization of the normalization	Lecture № 9
27.	Analyze quantum oscillator under the influence of an external force	Lecture № 8

28.	Give definition and describe perturbation theory for quasistationary states	Lecture № 9
29.	Analyze wave function of a multichannel system	Lecture № 10
30.	Explain the motion of two particles in an external potential field	Lecture № 13
31.	Explain section and unitarity of the S matrix	Lecture № 10
32.	Describe symmetry of the S matrix	Lecture № 10
33.	Give definition of S matrix and its relation to the R-matrix	Lecture № 11
34.	Explain threshold phenomena	Lecture № 11
35.	Characterize energy dependence of the scattering cross section near the threshold of reactions	Lecture № 11
36.	Describe generalization to the case of particles with spin	Lecture № 11
37.	Give definition and describe the Faddeev equations	Lecture № 12
38.	Describe general formulas for scattering cross sections	Lecture № 12
39.	Explain the motion of two particles in an external potential field	Lecture № 13
40.	Analyze the formula for determining the amplitudes of various processes	Lecture № 13
41.	Explain asymptotics of the wave function at large distances	Lecture № 13
42.	Explain and describe theory of weak interactions	Lecture № 14
43.	Analyze reactions with neutrino emission	Lecture № 14
44.	Describe quasienergy of a system subjected to periodic action	Lecture № 15
45.	Characterize multiplication in the case of several channels	Lecture № 15

Evaluation and attestation policy

Criteria-based evaluation:

Assessment of learning outcomes in correlation withdescriptors (verification of competence formation during midterm control andexaminations).

Summative evaluation:

evaluation of the presence and activity of the work in the classroom; assessment of the assignment, independent work of students, (project/casestudy/ program/...)

The formula for calculating the final grade.

$$\text{Final grade for the discipline} = \frac{\text{IC1} + \text{IC2}}{2} \cdot 0{,}6 + 0{,}1\text{MT} + 0{,}3\text{FC}$$

Below are the minimum estimates in percentage terms:

95% - 100%: A	90% - 94%: A-	85 % - 89%: B
80% - 84%: B	75% - 79%: B-	70% - 74%: C+
65% - 69%: C	60% - 64%: C-	55% - 59%: D+
50% - 54%: D-	0% -49%: F	

LITERATURES

1. Lectures of the European school on theoretical methods for electron and positron induced chemistry, Prague, Feb. 2005
2. E. Koelink, Lectures on scattering theory, Delft the Netherlands 200
3. H.Friedrich, Scattering Theory, Fachbereich Physik T 30aTU München Garching Germany, 2015
4. John R. Taylor Scattering Theory: The Quantum Theory of Nonrelativistic Collisions, 512 pages, Dover Publications, May 26, 2006
5. Ta-you Wu, Takashi Ohmura, Quantum Theory of Scattering, 528 pages, Dover Publications, July 19, 2011
6. D.S. Sivia, Elementary Scattering Theory: For X-ray and Neutron Users, 216 pages, Oxford University Press; 1 edition,January 29, 2011
7. Roger G. Newton, Scattering Theory of Waves and Particles: Second Edition, 768 pages, Dover Publications; Second edition, June 19, 2013
8. R.Blumenhagen, D.Lüst, S.Theisen, Basic Concepts of String Theory, 784 pages, Springer; 2013 edition, October 4, 2012