**Final exam program**

on discipline **“Modern computational methods in nuclear physics contents”** for 1st course doctoral students for specialty “6D060500 – Nuclear Physics”

The proposed program for the discipline **“Modern computational methods in nuclear physics contents”** 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; achieve learning outcomes of the course.

**The aim of the course:** learning the modern physics of atom nucleus and quantum mechanics of many-particle systems.

At the exam, students will be asked two theoretical questions (33 points each) and one practical question 34 point).

**Exam questions:**

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| --- | --- | --- |
|  | Explain introduction to the course "Programming and computer calculations in physics" | Lecture № 1 |
|  | Explain introduction to the system of Mathematica | Lecture № 1 |
|  | Analyze model of calculating | Lecture № 2 |
|  | Give definition and describe numbers and their representation and operations over them | Lecture № 2 |
|  | Explain arithmetic: the greatest common divisor and least common multiple | Lecture № 3 |
|  | Explain arithmetic: the decomposition of integers into prime factors | Lecture № 3 |
|  | Give definition of arithmetic: primenumbers | Lecture № 3 |
|  | Describe division with remainder, deductions, comparisons | Lecture № 4 |
|  | Explain the Chinese remainder theorem | Lecture № 4 |
|  | Analyze numerical functions | Lecture № 4 |
|  | Describe multimedia: geometry, graphics, cinema, sound | Lecture № 5 |
|  | Give the classification of factorization Factor Integer ECM | Lecture № 5 |
|  | Explain plotting | Lecture № 6 |
|  | Explain linear programming | Lecture № 6 |
|  | Give definition and describe nuclear forces | Lecture № 7 |
|  | Give definition of Nuclear Models | Lecture № 7 |
|  | Explain factorization of very large numbers | Lecture № 5 |
|  | Characterize nuclear forces and nuclear models | Lecture № 7 |
|  | Give the classification of Basic Concepts of Nuclear Physics | Lecture № 8 |
|  | Explain Toward a Unified Model Description of Nuclei | Lecture № 8 |
|  | Explain introduction to Nuclear Interactions and Reactions | Lecture № 9 |
|  | Describe Coulomb Excitation | Lecture № 9 |
|  | Explain Compound Nucleus Reactions | Lecture № 9 |
|  | Analyze Compound Nucleus Reactions and Other Reactions | Lecture № 9 |
|  | Describe Some Selected Applications of Nuclear Physics | Lecture № 9 |
|  | Characterize Radioactive Decay Laws | Lecture № 10 |
|  | Give definition of Alpha, Proton, Heavy Cluster | Lecture № 10 |
|  | Describe Spontaneous Fission Decays | Lecture № 10 |
|  | Explain Gamma Decay | Lecture № 10 |
|  | Give definition of Internal Conversion | Lecture № 10 |
|  | Explain Pair Production | Lecture № 10 |
|  | Describe Beta Decay | Lecture № 11 |
|  | Give definition of Radioactive Decay | Lecture № 11 |
|  | Explain Introduction to Nuclear Interactions and Reactions | Lecture № 11 |
|  | Characterize Reaction Kinematics | Lecture № 12 |
|  | Describe Fission and Fusion: Atomic Energy Utilization | Lecture № 12 |
|  | Explain Some Selected Applications of Nuclear Physics | Lecture № 13 |
|  | Analyze Nuclear Interactions and Reactions | Lecture № 13 |
|  | Give the classification of Magnetic Dipole Hyperfine Interaction | Lecture № 13 |
|  | Describe Electric Quadrupole Hyperfine Interaction | Lecture № 14 |
|  | Give defintion of Particle Families and Interactions | Lecture № 14 |
|  | Explain Conservation Rules | Lecture № 15 |
|  | Give definition and describe High-Energy Physics | Lecture № 15 |
|  | Describe Some Selected Applications of Nuclear Physics | Lecture № 13 |
|  | Explain Introduction to Nuclear Interactions and Reactions | Lecture № 11 |

***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.

Below are the minimum estimates in percentage terms:

95% - 100%: А 90% - 94%: А- 85 % - 89%: В

80% - 84%: В 75% - 79%: В- 70% - 74%: С+

65% - 69%: С 60% - 64%: С- 55% - 59%: D+ 50% - 54%: D- 0% -49%: F

**LITERATURES**

# P.Bodenheimer, G.P.Laughlin, M.Rozyczka, T.Plewa, H.W Yorke, Numerical Methods in Astrophysics: An Introduction, 344 pages, CRC Press, December 13, 2006

# M.Hjorth-Jensen, M.P.Lombardo, Ubirajara van Kolck, An Advanced Course in Computational Nuclear Physics: Bridging the Scales from Quarks to Neutron Stars, 644 pages, Springer; 1st ed. 2017 edition, June 7, 2017

# C.H.Holbrow, J.N.Lloyd, J. C. Amato, E.Galvez, M.E.Parks, Modern Introductory Physics, 658 pages, Springer; 2nd ed. 2010 edition, September 23, 2010

# Y.Azmy, E.Sartori, Nuclear Computational Science: A Century in Review, 470 pages, Springer; 2010 edition, May 14, 2010

# J.H Hamilton, F.Yang, Modern Atomic and Nuclear Physics, 797 pages, World Scientific Pub Co Inc; Revised edition, March 30, 2010

# Senior Fellow Continuous Electron Beam Accelerator Facility (Cebaf) Governor's Distinguished Cebaf Professor John Dirk Walecka, Theoretical Nuclear And Subnuclear Physics, 628 pages, Wspc/Icp; 2 edition, September 30, 2004

# A.Das, T.Ferbel, Introduction to Nuclear and Particle Physics, 416 pages, World Scientific Pub Co Inc; 2 edition, December 29, 2003