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| **Al-FARABI KAZAKH NATIONAL UNIVERSITY** Faculty of Mechanics and Mathematics **Department of Mathematical and Computer Modeling**  **SYLLABUS** Spectral Methods in Theoretical Physics **Autumnal semester (First half-year) 2016 – 2017 academic year, the bachelor, 3 course** | | | | | | | | | | | | | |
| **Course code** | | **Course name** | | **Type** | Hour per week | | | | | | | **Credits** | **ECTS** |
| **Lecture** | **Seminar** | | **Laboratory** | | | |
|  | | Spectral Methods in Theoretical Physics | | ED | **2** | **0** | | **1** | | | | **3** | **5** |
| Prerequisites | | | Mathematical Analysis, Algebra and Geometry, Information Science, Probability Theory and Mathematical Statistic, Stochastic Processes, ODE, PDE, Numerical Methods, Calculus, Calculations, Computations. | | | | | | | | | | |
| **Lecturer** | | | **Kanat Shakenov, Doctor of Physical and Mathematical Science, Professor** | | | | **Office-time** | | | According to timetable | | | |
| **e-mail:** | | | [shakenov@mail.ru](mailto:shakenov@mail.ru), [shakenov.kanat@kaznu.kz](mailto:shakenov.kanat@kaznu.kz). | | | |
| **Phone** | | | **+7 727 2211591, +7 705 182 3129** | | | | **Lecture hall** | | | **319** | | | |
| **Teacher (laboratory studies)** | | | **Madina Abdykarim**  **+7 747 2876780** | | | |  | | |  | | | |
| **e-mail:** | | | **abdykarim@gmail.com** | | | | **Lecture hall** | | | **201** | | | |
| **Course description** | | | Research of the stochastic models and theirs computer simulation. | | | | | | | | | | |
| **Course aims** | | | Destination of the course: calculation of the spectrums of operators. | | | | | | | | | | |
| **Learning outcomes** | | | 1. Intimate knowledge of the spectrums of operators. 2. Ability simulate of the spectrums of operators. | | | | | | | | | | |
| **References and resources** | | | 1. Shakenov K.K. Calculus Mathematics Methods. Course of Lectures. Tutorial. Almaty, “Print S”. 2009. 2. Demidovich B.P., Maron I.A., Shuvalova E.Z. Numerical Methods of Analysis. Third edition. Revised. Moscow, Nauka. 1967. 3. Serovajsky S.Ya. Introduction in Spectral Theory of Operators. Almaty, Publishing House “Alem”. 2003. 4. Данфорд Н., Шварц Дж.Т. Линейные операторы (общая теория). Москва. ИЛ. 1962. 5. Данфорд Н., Шварц Дж.Т. Линейные операторы (спектральная теория. Самосопряженные операторы в гильбертовом пространстве). Москва. Мир. 1966. 6. Hörmander L. The Analysis of Linear Partial Differential Operators I. Distribution Theory and Fourier Analysis. Springer-Verlag. Berlin Heidelberg New York Tokyo 1983. 7. Hörmander L. The Analysis of Linear Partial Differential Operators III. Pseudo-Differential Operators. Springer-Verlag. Berlin Heidelberg New York Tokyo 1985. 8. Volterra V. Theory of Functionals and of Integral and Integro-Differential Equations. Dover Publications, ING. New York 1959. 9. Бурбаки Н. Спектральная теория. – М., Мир, 1972. (In Russian). | | | | | | | | | | |
| **Course organization** | | | Structure of the course: 1.Lectures, 2. Laboratory**.** At a lectureto give the theoretical materials.At a laboratory to give stochastic calculations on PC. The homework may be preset (specified) according to the requirements. | | | | | | | | | | |
| **Course requirements** | | | 1. The students at first of theoretical materials (lectures) attend. They must to know theoretical materials. 2. Next, to conduct PC Laboratory. Student with PC must construct the numerical model and graphic plot. 3. Student on one's own (or with teacher) must know how computational process analyses. To draw a right conclusion and the model identify. | | | | | | | | | | |
| **Grading policy** | | | **Description of assignment** | | | | | **Weight** | **Learning outcomes** | | | | |
| Individual tasks  Group project  Analytical problem  Examinations.  Total | | | | | 35%  10%  15%  40%  100% | 1,2,34,5,6  2,3,4  4,5,6  1,2,3,4,5,6 | | | | |
| Your final score will be calculated by the formula  Below are minimum grades in percent:  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 | | | | | | | | | | |
| **Discipline policy** | | | All work must be performed and defend within a specified time. Students who do not pass a regular job or received for his performance at least 50 % of points, have the opportunity to work on additional specified job schedule. Students who missed labs for a good reason, and spend their extra time in the presence of a laboratory, after the admission of the teacher. Students who have not complied with all types of work for the exam are not allowed. Also, take into account when assessing the activity and attendance of students during class  Be tolerant and respect other people's opinions. Objections formulated in the correct form. Plagiarism and other forms of cheating are not allowed. Unacceptable prompting and copying during delivery SSS intermediate control and final exam, copying solved problems others, exam for another student. Student convicted of falsifying any information rate, unauthorized access to the Intranet using cribs, with a final grade «F».  For advice on the implementation of independent work (SSS), and surrender their protection as well as for more information on the studied material and all other emerging issues by reading a course, contact the instructor during his office hours. | | | | | | | | | | |
| **Discipline schedule** | | | | | | | | | | | | | |
| **Week** | **Topic** | | | | | | **Number of hours** | | | | **Maximum grade** | | |
| **1 – 2** | **Lecture 1 – 4.** Eigenvalues and Eigenvectors. Matrix Eigenvalue Problems. Properties of Eigenvalues and Eigenvectors. Iterative Methods. Power Iterations. Largest eigenvalue. QR iterations. | | | | | | **4** | | | | **8** | | |
| **1 – 2** | **Laboratory 1 – 4.** Iterative Methods. Power Iterations. Largest eigenvalue. QR Iterations. | | | | | | **4** | | | | **8** | | |
| **1 – 2** | **Students self-instruction (SSI) by subject (Homework, Project beginning etc. ) 1 – 4.**  Singular Value Decomposition. . | | | | | |  | | | | **4** | | |
| **3 – 4** | **Lecture 5 – 8.** Spectral Methods.Sturm – Liouville Problem. The Specters of Discretization Laplace Operator. Fourier Methods Solution of the Heat Conduction Equation. | | | | | | **4** | | | | **8** | | |
| **3 – 4** | **Laboratory 5 – 8.** PC Realization of Numerical Solution of the Heat Conduction Equation. | | | | | | **4** | | | | **8** | | |
| **3 – 4** | **SSI 5 – 8.** Heat Conduction Equation. | | | | | |  | | | | **4** | | |
| **5 – 6** | **Lecture 9 – 12.** Integral Equations. Fredholm and Volterra Integral Equations. Convergence method (Method of successive approximations, Step-by-step method). Finite sums method. Singular kernels method. Collocation method. Least-squares method. Method of moments. | | | | | | **4** | | | | **8** | | |
| **5 – 6** | **Laboratory 9 – 12.** PC realizationall Methods. | | | | | | **4** | | | | **8** | | |
| **5 – 6** | **SSI 9 – 12.** Fredholm and Volterra Integral Equations. | | | | | |  | | | | **4** | | |
| **7 – 11** | **Lecture 13 –22.** Fredholm Alternative. One-valued Solvability Criterion. Solution of System on Resolvent Set. The Structure of Specter of Matrix. Non-trivial Solution of Homogeneous System. Homogeneous System on Specter. The Spectral Theorem. The Specter of Self-Adjoint Operator. Spectral Decomposition of Unity. Spectral Decomposition of Operator. Finite Dimensional Spectral Theorem. (One- Two- Three- Dimensional Spectral Theorems). | | | | | | **10** | | | | **20** | | |
| **7 – 11** | **Laboratory 13 –22.** Praxis. Examples. Remarks. | | | | | | **10** | | | | **20** | | |
| **7 – 11** | **SSI 13 –14.** Praxis. Examples. | | | | | |  | | | | **10** | | |
|  | **IC 1** | | | | | |  | | | | **100** | | |
|  | **Midterm Exam** | | | | | |  | | | | **100** | | |
| **12 – 15** | **Lecture 23 –30. Applications.** **I.** Building of basis. **II.** Reduction of Operator to Canonical Form. Spectral Expansion of Operator. Canonical Form of Self-Adjoint Operator. **III.** Linear System of Algebraic Equations. Spectral Theorem and Fredholm Alternative. Fourier Method for Algebraic Equations. Resolvent. First order ODE. Abstract ODE. Homogeneous Dynamics System. Heterogeneous Dynamics System. process of bearings and deaths. Fourier Method for ODE. **IV.** Compact Theory. Finite Operators. Hilbert Space. Linear Continued and Compact Operators. The Structure of Compact Operator. Fredholm Alternative. Hilbert – Schmidt Theorem. Applications. **V.** Infinite Operators. Spectral Property of Infinite Operators. Applications. Boundary Problems of ODE and PDE. Heat Conduction Equation. Swing of the String Equation. | | | | | | **8** | | | | **16** | | |
| **12 – 15** | **Laboratory 15 –16.** Praxis. Examples. Remarks. | | | | | | **8** | | | | **16** | | |
| **12 – 15** | **SSI 15 –16.** Praxis. Examples. Remarks. | | | | | |  | | | | **8** | | |
|  | **IC 2** | | | | | |  | | | | **100** | | |
|  | **Exam** | | | | | |  | | | | **100** | | |
|  | **Total** | | | | | |  | | | | **100** | | |

##### Reviewed at the department meeting

***Report №\_\_ from «\_\_» \_\_\_\_\_\_\_\_\_\_\_\_2016***

**Head of department D. Zhakebayev**

**Lecturer K. Shakenov**