Skoltech
Skolkovo Institute of Science and Technology

Course Syllabus

Course Title (in English)	Mathematical Methods of Science
Course Title (in Russian)	Математические методы естествознания
Lead Instructor(s)	Sergei Khoroshkin

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1. Annotation

Course Description

The course is addressed to undergraduates of the first year and contains applications of various mathematical methods for solving problems of mathematical physics. The course assumes a minor familiarity with basic notions of classical mechanics and field theory on the example of solving specific problems. The main purpose of the course is to encourage undergraduates to independent research work. For this reason, the main element of the course is an independent solution to the problem, requiring the study of additional material. In the endpoint the students are assumed to acquire the use of Green functions, distributions, Laplace and Fourier transforms, asymptotic evaluations in mathematical physics

Course Prerequisites / Recommendations	It is assumed that students have basic mathematical courses included in the bachelor of physical and mathematical specialties.

Аннотация

Курс адресован в первую очередь магистрантам первого курса и содержит приложения различных математических методов для решения задач математической физики. Курс предполагает незначительное знакомство с базовыми понятиями классическая механики и теории поля на примере решения конкретных задач. Основной целью курса является стимулирование магистрантов к самостоятельной научно-исследовательской работе. По этой причине основным элементом курса является самостоятельное решение задачи, требующее изучения дополнительного материала. Предполагается, что в конечной точке студенты овладеют использованием функций Грина, распределений, преобразований Лапласа и Фурье, асимптотических оценок в математической физике

2. Structure and Content

Course Academic Level	Master-level course suitable for PhD students
Number of ECTS credits	6

Topic	Summary of Topic	Lectures (# of hours)	Seminars (# of hours)	Labs (# of hours)
Harmonic oscillator.	The motion of a harmonic oscillator under the action of the driving force. The retarded green function. The causal green function. Green function for Cauchy and boundary problems of ODE	2	4	
Distributions.	Distributions. Regular and singular generalized functions. Sokhotskii formula. The Fourier transform of generalized functions. The electrostatic problem.	2	5	
A quantum particle in a two-dimensional shallow pit.	Laplace's method for solving linear differential equations of second order. Bessel functions, their asymptotics. The method of the pass. Airy-Fock function , its asymptotics.	1	4	
Laplace transform.	Laplace transform and its properties. Applications to ordinary differentiak equations	1	4	
The solution of Maxwell's equations.	The fundamental solution of the wave equation. Analytical properties of green functions. The retarded, advanced and causal green's functions.	1	4	
Asymptotical expansions	Properties of asymptotical expansions. Asymptotics of solutions of transcendental equations	2	6	
Saddle point method	Asymptotics of Laplace and Fourier integrals. Saddle point approximations	1	7	
Euler-Maclauren formula	Euler-Maclauren formula and its applications. Asymptotical expansion of harmonic series and logarithm of Gamma function	1	4	

3. Assignments

Assignment Type	Assignment Summary
Problem Set	The students will be given a list of problems that cover the course and are supposed to show the understanding of basic knowledge and ability to use main technical tools.

4. Grading

Type of Assessment Graded

Grade Structure

Activity Type	Activity weight, %
Homework Assignments	25
Homework Assignments	25
Homework Assignments	25
Final Exam	25

Grading Scale

A:	86
B:	76
C:	66
D:	56
E:	46
F:	0

Attendance Requirements Optional

5. Basic Information

Maximum Number of Students

	Maximum Number of Students
Overall:	25
Per Group (for seminars and labs):	25

Course Stream	Science, Technology and Engineering (STE)
Course Term (in context of Academic Year)	Term 1 Term 2
Course Delivery Frequency	Every year

Students of Which Programs do You Recommend to Consider this Course as an Elective?

Masters Programs	PhD Programs
Mathematical and Theoretical Physics	Mathematics and Mechanics

Course Tags	Math Physics

6. Textbooks and Internet Resources

Required Textbooks	ISBN-13 (or ISBN-10)
Vladimirov V. S. Equations of mathematical physics //MolzN. – 1976.	978-0828528771
Gel'fand I., Shilov G. Generalized Functions vol 1 (Moscow: Fizmatgiz). – 1959.	978-1-4704-2658-3

Recommended Textbooks	ISBN-13 (or ISBN-10)
Whittaker, Edmund Taylor, and George Neville Watson. A course of modern analysis. Dover Publications, 2020.	9780486842868
Erdélyi A. Asymptotic expansions. – Courier Corporation, 1956. – №. 3.	978-0486603186

7. Facilities

8. Learning Outcomes

Knowledge
1.Green functions of boundary and Cauchy problems for ordinary differential equations 2.Differential equations with complex time. Laplace substitution. Laplace transform. 3.Distributions. Fourier transform of distributions 4.Fundamental solutions of classical differential operators of the second order. Applications to the problems of mathematical physics. Different kinds of the Green functions 5.Asymptotical evaluations and asymptotical expansions. Evaluations of Laplace and Fourier integrals. Saddle point method in real and complex forms

Skill
The main purpose of the course is to encourage undergraduates to independent research work

Experience
In the endpoint the students are assumed to acquire the use of Green functions, distributions, Laplace and Fourier transforms, asymptotic evaluations in mathematical physics

9. Assessment Criteria

Input or Upload Example(s) of Assigment 1:

Select Assignment 1 Type	Homework Assignments
Input Example(s) of Assignment 1 (preferable)	https://math.hse.ru/data/2016/11/27/1112723454/listok6_2016.pdf
Assessment Criteria for Assignment 1	We assume: 3 written homeworks and oral exam. Total evaluation is the sum of evaluations of homeworks and exam (0,25 of each grade). Active work during the seminars also raise the final grade

Input or Upload Example(s) of Assigment 2:

Input or Upload Example(s) of Assigment 3:

Input or Upload Example(s) of Assigment 4:

Input or Upload Example(s) of Assigment 5:

10. Additional Notes