Riga Technical University

University of Latvia

RTU/LU Course

General data

Code	HEP008
Course title	Mathematics for Particle Physics
Course status in the programme	Obligatory Choice
Course level	Doctoral Studies
Course type	Academic
Field of study	High-Energy Physics
Responsible instructor	prof. Vyacheslavs Kashcheyevs-
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS
Language of instruction	EN
Possibility of distance learning	Not planned
Abstract	This course introduces the necessary mathematical background for understanding the high-energy particle physics. The course covers four major topics: mathematics of special relativity, description of symmetries in terms of group theory, fundamentals of complex analysis and selected topics in special functions. Selection of material is focused on the needs of particle physics, with application examples closely aligned with the topics in the obligatory choice course "Introduction to particle physics" and the obligatory course "Particle physics theory". Elementary examples and physics applications are favoured over formal treatment and rigorous proofs. Thus, groups are introduced via spatial translations and rotations, Lorentz transformations, isospin and colour; properties of analytic functions are applied to the physics of scattering amplitudes (causality, unitarity, crossing symmetry), etc.
Goals and objectives of the course in terms of competences and skills	The students will acquire the following skills and competences: • Use Lorenz transformations and conceptualize them as group transformations. • Solve simple kinematical problems in relativistic particle collisions. • Understand the concept of group representation and recognize irreducible representations in physical properties of particles and fields. • Become familiar with the concepts of Lie algebra, representation weights and Young tableaux, learn how to construct irreducible representations of Lie groups. • Understand the concepts of analyticity, Riemann surface, singularities of analytic functions. Learn to evaluate simple integrals involving analytic functions. • Use Fourier transform and special functions for mathematical description of quantum scattering. .
Structure and tasks of independent studies	The independent studies will take the form of further reading and some homework throughout the course. The students will be given problems of increasing difficulty to attempt at home with the aim of them being able to complete at least one problem in a set and attempt the rest. The further reading will be given in the form of recommendations of various sources of information, including textbooks, and material available online.
Recommended literature	1. Sexl R.U. and Urbantke H.K., *Relativity, Groups, Particles*, Springer, ISBN: 9783211834435 2. Churchill R. V. and Brown J.W., *Complex Variables and Applications*, ISBN: 9780070109056 3. Sternberg, S., *Group Theory and Physics*, ISBN: 9780521558853 4. Akhmedova, V. and Akhmedov E. T., *Selected Special Functions for Fundamental Physics*, ISBN: 9783030350888
Course prerequisites	Calculus, linear algebra
Courses acquired before	-

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
Mathematics of special relativity and relativistic collisions	10	20	-	-
Group theory for particle physics	15	30	-	-
Introduction to complex analysis	15	40	-	-
Selected special functions and integral transforms	10	20		
Total:	50	110	-	-

Riga Technical University

University of Latvia

Learning outcomes and assessment

Learning outcomes	Assessment methods
Demonstrated ability to solve simple mathematical problems in the following domains • Application of Lorentz transformations to elementary relativistic problems. • Kinematical problems in relativistic particle collisions. • Identifying singularities of analytics functions typical to particle physics. • Perform integration in complex plane. • Operate with Lie algebras, Young tableaux, and irreducible representations of Lie groups. • Apply Fourier transform in the context of quantum scattering theory. • Use properties of special functions in mathematical transformations.	Homework problems
Students can explain key concepts of group theory and theory of functions of complex variable, and are able illustrate the application of these concepts in particle physics.	Oral examination

Evaluation criteria of study results

Criterion	%
Homework problem sets	80
Oral examination	20
Total:	100%

Course planning

Part	Semester			CP	ECTS	Hours per Week			Tests			Tests (free choice)		
	Autumn	Spring	Summer			Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.	*			2.0	2.0	10	-	-		*	*			