Study plan

Name of study plan: Matematická fyzika

Faculty/Institute/Others:

Department:

Branch of study guaranteed by the department: Welcome page

Garantor of the study branch:

Program of study: Mathematical Physics Type of study: Follow-up master full-time

Required credits: 0

Elective courses credits: 120 Sum of credits in the plan: 120

Note on the plan:

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 0

The role of the block: P

Code of the group: NMSPMF1

Name of the group: MDP P_MFN 1st year

Requirement credits in the group:

Requirement courses in the group: In this group you have to complete at least 9 courses

Credits in the group: 0 Note on the group:

Note on the grou	ν.					
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
02GMF2	Geometric Methods in Physics 2 Jan Vysoký Jan Vysoký Libor Šnobl (Gar.)	Z,ZK	5	2+2	L	Р
02GR	Groups and Representations Goce Chadzitaskos, Lenka Motlochová Lenka Motlochová Goce Chadzitaskos (Gar.)	Z,ZK	3	2+1	Z	Р
02KFA	Quantum Physics Michal Jex Michal Jex Igor Jex (Gar.)	Z,ZK	6	4P+2C	L	Р
02KTPA1	Quantum Field Theory 1 Václav Zatloukal Václav Zatloukal Martin Štefa ák (Gar.)	Z,ZK	8	4P+2C	Z	Р
02KTPA2	Quantum Field Theory 2 Petr Jizba Václav Zatloukal Martin Štefa ák (Gar.)	Z,ZK	8	4P+2C	L	Р
02LAG	Lie Algebras and Lie Groups Libor Šnobl Martin Štefa ák Libor Šnobl (Gar.)	Z,ZK	7	4P+2C	Z	Р
02VUMF1	Research Project 1 Jan Vysoký Libor Šnobl (Gar.)	Z	6	6	Z,L	Р
02VUMF2	Research Project 2 Jan Vysoký, Libor Šnobl, Václav Zatloukal, Martin Štefa ák, Petr Jizba, Josef Schmidt, David Krej i ík, Mat j Tušek, Ji í Tolar Aurél Gábor Gábris Libor Šnobl (Gar.)	KZ	8	8	L,Z	Р
02ZS	Winter School of Mathematical Physics Ji í Hrivnák Ji í Hrivnák (Gar.)	Z	1	1týd.	Z	Р

Characteristics of the courses of this group of Study Plan: Code=NMSPMF1 Name=MDP P_MFN 1st year

02GMF2	Geometric Methods in Physics 2	Z,ZK	5		
A theory of gauge fields forms the foundation of contemporary particle physics, namely of the Standard Model. The main goal of this course to to acquaint students with the mathema					
apparatus required for i	apparatus required for its geometric description. We will focus on theory of principal fiber bundles and the interpretation of gauge fields as connection forms on principal fiber bundles				
All theoretical concepts	are demonstrated on particular examples, e.g. frame bundle, Hopf fibration and Yang-Mills field.				
02GR	Groups and Representations	Z,ZK	3		
The aim of the lectures	is to acquaint students with the basic concepts of discrete group theory and their representations. The student will be thorou	ghly acquainted w	vith the methods		
of classification of finite	groups, decomposition of groups into direct and semidirect products, and with the properties of reducible and irreducible rep	resentations.			
02KFA	Quantum Physics	Z,ZK	6		
The goal of the lecture	s formulating and developing quantum theory as a physically motivated, but mathematically rigorous theory built upon the an	alysis of bounded	and unbounded		
linear operators on separable Hilbert spaces. Previous knowledge of quantum mechanics is an advantage but not a predisposition for the course. The pivot point is the establishing of					
the main postulates of t	he theory and deriving their consequences for model systems, as well as a detailed study of the most commonly used observ	ables in quantum	mechanics. The		
lecture focuses on the	exactness and proofs of the statements. Some common mistakes resulting from breaking the assumptions of these are also c	discussed.			

02KTPA1 Quantum Field Theory 1 The lecture aims to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relativistic quantum mechanics, canonical quantization of scalar and bispinor field, perturbation theory (Feynmans rules) and basics of renormalization. The content of the lecture can serve as a base for further study

in fields of exactly solvable models, theory of critical phenomena, molecular chemistry and biochemistry or quantum gravity. Quantum Field Theory 2

The lecture aims at introducing the students to the Feynmans functional integral and its applications. The focus is on broadening the knowledge of modern parts of relativistic and non-relativistic quantum field theory and statistical physics. The content of the lecture can serve as a base for further study in fields of exactly solvable models, theory of critical phenomena, molecular chemistry and biochemistry or quantum gravity.

02LAG Lie Algebras and Lie Groups

The aim of the lectures is get students familiar with the basic concepts of the theory of Lie groups and Lie algebras, and their finite-dimensional representations. The students will also learn Cartan's classification of simple complex Lie algebras, which is the fundamental result in this field of mathematics, including its derivation. Emphasis is put on detailed investigation

02VUMF1 Research Project 1 The research project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common

regular meetings and discussions. Research Project 2 02VUMF2

The research project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common regular meetings and discussions.

Winter School of Mathematical Physics 02ZS

of explicit examples of the introduced mathematical structures and their applications.

Ζ

The aim of the winter school of mathematical physics is to significantly improve presentation skills of the students and their ability to follow specialized conference presentations in English. Each student presents a specialized talk in English on the topic of his/her own research. The goal is to create such suitable conditions that motivate students towards a rigorous formulation of their own research together with high quality specialized presentation and abstract. The scientific level of the student presentations is guaranteed by audience comprising experts from CTU and other universities.

Code of the group: NMSPMF2

Name of the group: MDP P MFN 2nd year

Requirement credits in the group:

Requirement courses in the group: In this group you have to complete at least 5 courses

Credits in the group: 0 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
02ALT	Algebraic Topology Jan Vysoký Jan Vysoký (Gar.)	Z,ZK	4	2P+2C	Z	Р
02DPMF1	Master Thesis 1 David Krej i ik Libor Šnobl (Gar.)	Z	10	10	Z,L	Р
02DPMF2	Master Thesis 2 David Krej i ík Libor Šnobl (Gar.)	Z	20	20	L,Z	Р
02DSMF	Diploma Seminar Ji í Hrivnák Ji í Hrivnák (Gar.)	Z	1	0P+2C	L	Р
02VPSFA	Selected Topics in Statistical Physics and Thermodynamics	Z,ZK	7	4P+2C	Z	Р

Characteristics of the courses of this group of Study Plan: Code=NMSPMF2 Name=MDP P MFN 2nd year

02ALT Algebraic Topology 7.7K A study of modern mathematical and theoretical physics requires one to acquire an ever increasing knowledge of mathematical apparautus. The main goal of this course is to acquaint students with basic methods used in algebraic topology, namely elements of category theory, homototopies, homological algebra and cohomology. An important objective is to enhance the mathematical language by concepts appearing universally across disciplines like differential geometry and abstract algebra. During excercise sessions, students will try practical calculations of introduced mathematical structures.

02DPMF1 Master Thesis 1 The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common

regular meetings and discussions 02DPMF2 Master Thesis 2

The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common

regular meetings and discussions. Diploma Seminar 02DSMF

In the first part of the seminar, students familiarize themselves with the general principles of publishing and presenting scientific work and the formal requirements for diploma projects at the faculty. The second part is designed as a practical training for the defence of the diploma project. The students give oral presentations of the current state of the research results achieved during the work on their projects. Each presentation is followed by a discussion on scientific matters as well as on the possibilities of improving the students performance.

02VPSFA Selected Topics in Statistical Physics and Thermodynamics Z,ZK

The course concentrates on some advanced topics of statistical mechanics not discussed in the basic course on thermodynamics and statistical physics. Question concerning density matrices, the behaviours of nonideal gases and its macroscopic description, microscopic description of phase transitions, the role of fluctuations are addressed in detail.

Name of the block: Elective courses Minimal number of credits of the block: 0

The role of the block: V

Code of the group: NMSPMFV

Name of the group: MDP P_MFN Optional courses

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0 Note on the group:

Note on the g	Name of the course / Name of the group of courses					
Code	(in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
01ASY	Asymptotical Methods Ji í Mikyška Ji í Mikyška (Gar.)	Z,ZK	3	2+1	Z	V
02COX	Coxeter Groups Ji í Hrivnák Ji í Hrivnák Ji í Hrivnák (Gar.)	Z	2	2+0		V
01FAN3	Functional Analysis 3 Pavel Š oví ek Pavel Š oví ek Pavel Š oví ek (Gar.)	Z,ZK	5	2P+2C	Z	V
02FG	Physics of graphene described by Dirac equation Vit Jakubský Vít Jakubský (Gar.)	Z	2	2P+0C	L	V
01SPEC	Geometrical Aspects of Spectral Theory David Krej i fk David Krej i fk David Krej i fk (Gar.)	ZK	2	2+0	L	V
02GSKS	Groups of symmetry of quantum systems Ji í Tolar Martin Štefa ák Ji í Tolar (Gar.)	ZK	2	26P	Z	٧
02INB	Integrability and beyond Libor Šnobl, Antonella Marchesiello Libor Šnobl Libor Šnobl (Gar.)	Z	2	2P+0C		٧
02KCH	Quantum Chemistry Michal Jex Michal Jex (Gar.)	Z,ZK	3	2P+1C	Z	V
02QIC	Quantum Information and Communication Aurél Gábor Gábris Aurél Gábor Gábris Martin Štefa ák (Gar.)	Z,ZK	4	3P+1C	Z	V
02KO1	Quantum Optics 1 Václav Poto ek Václav Poto ek Igor Jex (Gar.)	Z,ZK	4	2P+2C	Z	V
02KO2	Quantum Optics 2 Václav Poto ek Václav Poto ek Igor Jex (Gar.)	Z,ZK	4	2P+2C	L	V
01KVGR1	Quantum Groups 1 estmír Burdík estmír Burdík (Gar.)	Z	2	2+0	Z	V
02KVK1	Quantum Circle 1 Martin Štefa ák Pavel Exner (Gar.)	Z	2	0+2	Z	V
02KVK2	Quantum Circle 2 Martin Štefa ák Pavel Exner (Gar.)	Z	2	0+2	L	V
01MMNS	Mathematical Modelling of Non-linear Systems Michal Beneš Michal Beneš Michal Beneš (Gar.)	ZK	3	1P+1C	Z	V
02NGR	Numerical Relativity Josef Schmidt Josef Schmidt (Gar.)	ZK	2	2P+0C	L	V
02OKS	Open Quantum Systems Jaroslav Novotný Martin Štefa ák Jaroslav Novotný (Gar.)	Z	2	2+0		V
02PPKT	Advanced Topics of Quantum Theory Pavel Exner Martin Štefa ák Pavel Exner (Gar.)	ZK	2	2+0	L	V
02QPRGA	Quantum Programming Aurél Gábor Gábris, Iskender Yalcinkaya Aurél Gábor Gábris Aurél Gábor Gábris (Gar.)	Z	3	1P+1C	L	V
02REL1	Relativistic Physics I Old ich Semerák Martin Štefa ák	Z,ZK	6	4+2	Z	V
02REL2	Relativistic Physics 2 Old ich Semerák Martin Štefa ák Old ich Semerák (Gar.)	Z,ZK	6	4+2	L	٧
02RMMF	Solvable Models of Mathematical Physics Ladislav Hlavatý Martin Štefa ák Ladislav Hlavatý (Gar.)	Z	2	2+0	L	٧
02SKTPE1	Seminar on quantum field theory 1 Petr Jizba Petr Jizba (Gar.)	Z	3	2P+1C	Z	V
02SKTPE2	Seminar on quantum field theory 2 Petr Jizba Václav Zatloukal Petr Jizba (Gar.)	Z	3	2P+1C	L	V
01TG	Graph Theory Jan Volec, Petr Ambrož Petr Ambrož Petr Ambrož (Gar.)	ZK	5	4P+0C		٧
01NAH	Theory of Random Processes Jan Vybíral Jan Vybíral (Gar.)	ZK	3	3+0	Z	V
02UST1	Introduction to Strings 1 Jan Vysoký, Ladislav Hlavatý Jan Vysoký Ladislav Hlavatý (Gar.)	Z	3	2+1	Z	V
02UST2	Introduction to Strings 2 Jan Vysoký, Ladislav Hlavatý Jan Vysoký Ladislav Hlavatý (Gar.)	Z	3	2+1	L	V
01VAM	Variational Methods Michal Beneš Michal Beneš (Gar.)	ZK	3	1P+1C	Z	V

Characteristics of the courses of this group of Study Plan: Code=NMSPMFV Name=MDP P_MFN Optional courses

01ASY Asymptotical Methods Z,ZK 3
Examples. Addition parts of mathematical analysis (generalized Lebesgue integral, parametric integrals.) Asymptotic relations a expansions - properties; algebraical and analytical operations. Applied asymptotics of sequences and sums; integrals of Laplace and Fourier type.

02COX			
	Coxeter Groups	Z	2
The course is an introde	ction to the theory of Coxeter groups and their invariant theory. The case of the finite Coxeter groups - the reflection groups	and their propertie	es are studied.
•	chamber and length are defined. General theory of the Coxeter groups, the corresponding bilinear forms and the theory of the		
=	lection groups. The study of affine Weyl groups and related objects forms basic example of infinite Coxeter groups. As an intr	roduction to the inv	variant theory
	and the Weyl identity are presented.		_
01FAN3	Functional Analysis 3	Z,ZK	5
•	ional analysis needed for theory of representations of Lie groups and quantum theory. Compact operators, their ideals, unbou	•	perators, theory
	of symmetric operators, Stones theorem, quadratic forms and Bochner integral. The basics of Banach algebras and C*-algebras an		
02FG	Physics of graphene described by Dirac equation	Z	2
•	crystal. Tight-binding model of graphene and its approximation in terms of Dirac equation. Transport of Dirac fermions in graph		
· ·	 Bilayer graphene, its description and properties in the external magnetic field. Carbon nanotubes, their classification. Basic conditions and energy. Dirac fermions in curved space, fullerenes. Other Dirac materials. 	description of gra	prierie
-		71/	
01SPEC	Geometrical Aspects of Spectral Theory	ZK	2 Florents of
	s of classical physics and the rise of quantum mechanics. Mathematical formulation of quantum theory. Spectral problems in discrete and essential spectra. Sobolev spaces. Quadratic forms. Schrödinger operators. 3. Stability of the essential spectrur		
-	ation methods. 4. The role of the dimension of the Euclidean space. Criticality versus subcriticality. The Hardy inequality. Stabi		
•	ssification of Euclidean domains and their basic spectral properties. 6. Vibrational systems. The symmetric rearrangement and	•	
•	7. Quantum waveguides. Elements of differential geometry: curves, surfaces, manifolds. Effective dynamics. 8. Geometrically		
Hardy-type inequalities	in tubes.		
02GSKS	Groups of symmetry of quantum systems	ZK	2
	for the students of Mathematical Physics - is aimed to introduce them to advanced topics connected with applications of gro	up theory in quant	um physics.
Starting with the Wigne	r theorem on symmetry operations in quantum physics, the classification of projective representations of Lie groups as well a	s the superselecti	on rules will be
dealt with. The groups in	mportant in physics the Euclid, the Poincaré and the Galilei group will be treated by Mackeys method of induced representati	ons.	
02INB	Integrability and beyond	Z	2
Abstract: Hamiltonian s	stems and their integrals of motion. Hamilton-Jacobi equation and separation of variables. Classification of integrable system	ns with integrals p	olynomial in
momenta. Superintegra	bility. Perturbative methods in the study of Hamiltonian systems.		
02KCH	Quantum Chemistry	Z,ZK	3
Introduction to quantum	chemistry. Students will acquire theoretical and practical skills to solve basic problems of theoretical quantum chemistry with	n focus on electror	nic structure.
02QIC	Quantum Information and Communication	Z,ZK	4
Quantum theory brough	t new ideas to the theory of information leading which ultimately lead to the theory of quantum information, computation and	communication. T	The lecture
introduces the basic co	ncepts of quantum information e.g. quantum algorithms (Shors and Grovers), entanglement, quantum teleportation, quantum	cryptography and	d quantum error
correction. It also provid	es an introduction to modern parts of quantum information, e.g. measurement-based and adiabatic quantum computation ar	nd quantum walks	-
02KO1	Quantum Optics 1	Z,ZK	4
	optics, the course shows the construction of a semiclassical Quantum Optics theory of light and light-matter interaction. The		-
	ne qualitative and quantitative description of a broad range of quantum optical phenomena as well as some methods for prac		
02KO2	Quantum Optics 2	Z,ZK	4
This course completes	Quantum Optics 1 by teaching the terminology and computational methods related to the reformulation of Quantum Optics in		
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application areas to cor	tinuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts		
application areas to cor applications in further e	tinuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts experimental research is also provided.	of Quantum Option	cs as well as its
application areas to cor applications in further e 01KVGR1	tinuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts xperimental research is also provided. Quantum Groups 1	of Quantum Option	es as well as its
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application areas to cor applications in further e 01KVGR1 Quantum Algebra was of They have many applications of the Dopple 02KVK1 Seminars of the Dopple 02KVK2 Seminars of the Dopple 01MMNS The course consists of bifurcations and chaos. 02NGR The general theory of reastrophysically relevant reformulation of the star of general relativity ther holes and the extraction 02OKS Quantum description of possible applications. Ir of state changes, super description of decohere 02PKT Linear operators in Hilb an overlap with 01KF, c 02QPRGA The goal of the course is protocols and quantum implemented with Pythobachelor and masters sand make it internations.	tinuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts perimental research is also provided. Quantum Groups 1 riginated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in or ations in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and Quantum Circle 1 Institute on topics of mathematical quantum physics for students and PhD. students. Quantum Circle 2 Institute on topics of mathematical quantum physics for students and PhD. students. Mathematical Modelling of Non-linear Systems basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary different Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systemical study is currently the most accurate theory of gravity. However, the great complexity of Einstein's equations means that we solutions. With the development of computers, however, the possibility to simulate spacetimes numerically has emerged, but dard theory. The main part of the course will therefore be devoted to formulating Einstein's equations in a form suitable for so include coordinate freedom and the potential presence of physical singularities. In the course, we will also get to application of gravitational waves. Open Quantum Systems composite subsystems and their subsystems, density operator. Pure and mixed states, entropy. Quantum correlations, entar troduction to theory of generalized quantum measurement, positive operator-valued measure, physical realizations. Quantum poperator theoretical framework, examples of quantum operations. Markovian quantum master equation, quantum dynamical note and thermalization. Advanced Topics of Quantum Theory et spaces, the uncertainty relations, the canonical commutational relations, the Stone theorem, algebras of observable	der to solve integrethe string theory. Z Z Z ZK ial equations, and ystems. ZK know only a very this requires a significant points such as the local points and ystems. ZK solving the initial properties as the local points such as the local points are greatly as a semigroups. Basic points are greatly as on how these conwork. The course is a most out of the lafterer the course string theory.	2 able models. 2 able models. 2 2 3 description of 2 few analytically gnificant oblem. Specifics alization of black 2 properties and eral description of models for 2 rators. There is 3 communication neepts are s suitable for earning material art is required.
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application areas to cor applications in further e 01KVGR1 Quantum Algebra was of They have many applications of the Dopple 02KVK1 Seminars of the Dopple 02KVK2 Seminars of the Dopple 01MMNS The course consists of bifurcations and chaos. 02NGR The general theory of reastrophysically relevant reformulation of the star of general relativity ther holes and the extraction 02OKS Quantum description of possible applications. In of state changes, super description of decohere 02PKT Linear operators in Hilb an overlap with 01KF, co 02QPRGA The goal of the course is protocols and quantum implemented with Pythobachelor and masters sand make it internations 02REL1	tinuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts perimental research is also provided. Quantum Groups 1 riginated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in or ations in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and Quantum Circle 1 Institute on topics of mathematical quantum physics for students and PhD. students. Quantum Circle 2 Institute on topics of mathematical quantum physics for students and PhD. students. Mathematical Modelling of Non-linear Systems basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary different Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systemical study is currently the most accurate theory of gravity. However, the great complexity of Einstein's equations means that we solutions. With the development of computers, however, the possibility to simulate spacetimes numerically has emerged, but dard theory. The main part of the course will therefore be devoted to formulating Einstein's equations in a form suitable for so include coordinate freedom and the potential presence of physical singularities. In the course, we will also get to application of gravitational waves. Open Quantum Systems composite subsystems and their subsystems, density operator. Pure and mixed states, entropy. Quantum correlations, entar troduction to theory of generalized quantum measurement, positive operator-valued measure, physical realizations. Quantum poperator theoretical framework, examples of quantum operations. Markovian quantum master equation, quantum dynamical note and thermalization. Advanced Topics of Quantum Theory et spaces, the uncertainty relations, the canonical commutational relations, the Stone theorem, algebras of observable	der to solve integrithe string theory. Z Z Z Z Z Z Z Z Z Z Z Z Z	2 able models. 2 able models. 2 2 3 description of 2 few analytically gnificant oblem. Specifics alization of black 2 properties and eral description comodels for 2 rators. There is 3 communication incepts are s suitable for earning material art is required.

02REL2	Relativistic Physics 2	Z,ZK	6
Lagrangian formali	ism and conservation laws in general relativity. Initial value problem, 3+1 splitting and Gauss-Codazzi equations. Hamiltonian fo	rmalism in general re	lativity. Causal
structure of spacet	ime. Geometry of timelike and null congruences.		
02RMMF	Solvable Models of Mathematical Physics	Z	2
Elementary method	ds for solving nonlinear differential equations occuring in mathematical physics are explained.	,	
02SKTPE1	Seminar on quantum field theory 1	Z	3
The lecture aims to	o introduce the students to advanced topics of quantum field theory. The focus is mainly on quantization with Feynmans functio	nal integral.	
02SKTPE2	Seminar on quantum field theory 2	Z	3
The lecture aims to	o introduce the students to advanced topics of quantum field theory. The focus is mainly on quantization with Feynmans functio	nal integral.	
01TG	Graph Theory	ZK	5
01TG 1. Basic notion of g	Graph Theory graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Ma	1	-
1. Basic notion of g		atrix-Tree Theorem).	6. Euler tours
Basic notion of g and Hamilton cycle	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Ma	atrix-Tree Theorem).	6. Euler tours
Basic notion of g and Hamilton cycle	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mass. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory.	atrix-Tree Theorem).	6. Euler tours
Basic notion of gand Hamilton cycle graphs. 12. Spectru O1NAH	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mass. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski	atrix-Tree Theorem). (theorem), vertex col	6. Euler tours oring of planar
Basic notion of gand Hamilton cycle graphs. 12. Spectru O1NAH The course is devo	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mass. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes	atrix-Tree Theorem). (theorem), vertex col	6. Euler tours oring of planar
Basic notion of gand Hamilton cycle graphs. 12. Spectru NAH The course is devostationary ones.	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mess. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes sted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and	atrix-Tree Theorem). (theorem), vertex col	6. Euler tours oring of planar
1. Basic notion of g and Hamilton cycle graphs. 12. Spectru 01NAH The course is devo stationary ones. 02UST1	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mass. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes	atrix-Tree Theorem). theorem), vertex col	6. Euler tours oring of planar 3 kly and strongl
1. Basic notion of g and Hamilton cycle graphs. 12. Spectru 01NAH The course is devo stationary ones. 02UST1	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mess. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes sted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and Introduction to Strings 1 ture is to present the basics the (super)string theory	atrix-Tree Theorem). theorem), vertex col	6. Euler tours oring of planar 3 kly and strongl
1. Basic notion of g and Hamilton cycle graphs. 12. Spectru 01NAH The course is devo- stationary ones. 02UST1 The goal of the lect 02UST2	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mess. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes sted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and Introduction to Strings 1	atrix-Tree Theorem). theorem), vertex columns ZK sequences both wea	S. Euler tours oring of planar 3 kly and strongl
1. Basic notion of g and Hamilton cycle graphs. 12. Spectru 01NAH The course is devo stationary ones. 02UST1 The goal of the lect 02UST2	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mess. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes sted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and Introduction to Strings 1 sture is to present the basics the (super)string theory Introduction to Strings 2 sture is to develop the basics the (super)string Theory explained in UST1	atrix-Tree Theorem). theorem), vertex columns ZK sequences both wea	S. Euler tours oring of planar 3 kly and strongl
1. Basic notion of g and Hamilton cycle graphs. 12. Spectru 01NAH The course is devo stationary ones. 02UST1 The goal of the lect 02UST2 The goal of the lect 01VAM	graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Mess. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski um of the adjacency matrix. 13. Extremal graph theory. Theory of Random Processes sted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and Introduction to Strings 1 ture is to present the basics the (super)string theory Introduction to Strings 2	atrix-Tree Theorem). theorem), vertex columns theorem, vertex columns zK sequences both wear Z	3 kly and strongl

List of courses of this pass:

Code	Name of the course	Completion	Credits
01ASY	Asymptotical Methods	Z,ZK	3
Examples. Addi	tion parts of mathematical analysis (generalized Lebesgue integral, parametric integrals.) Asymptotic relations a expansions - propert operations. Applied asymptotics of sequences and sums; integrals of Laplace and Fourier type.	ies; algebraical and	analytical
01FAN3	Functional Analysis 3	Z,ZK	5
•	functional analysis needed for theory of representations of Lie groups and quantum theory. Compact operators, their ideals, unbound selfadjoint extension of symmetric operators, Stones theorem, quadratic forms and Bochner integral. The basics of Banach algebras a		ators, theory
01KVGR1	Quantum Groups 1	Z	2
_	ra was originated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in ord re many applications in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems	-	
01MMNS	Mathematical Modelling of Non-linear Systems	ZK	3
	ists of basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary differential cations and chaos. Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dy		scription of
01NAH	Theory of Random Processes	ZK	3
The course is dev	oted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and sequentially to the sequential theory of stationary processes and sequentially to the sequential theory of stationary processes and sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of stationary processes are sequential to the sequential theory of sequential theory of sequential theory of sequential the	ences both weakly	and strongly
01SPEC	Geometrical Aspects of Spectral Theory	ZK	2
aspects. Glazma	perturbation methods. 4. The role of the dimension of the Euclidean space. Criticality versus subcriticality. The Hardy inequality. Stabi in's classification of Euclidean domains and their basic spectral properties. 6. Vibrational systems. The symmetric rearrangement and requency. 7. Quantum waveguides. Elements of differential geometry: curves, surfaces, manifolds. Effective dynamics. 8. Geometrically Hardy-type inequalities in tubes.	the Faber-Krahn in	equality for
01TG	Graph Theory	ZK	5
	of graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Matrix- cles. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski theo graphs. 12. Spectrum of the adjacency matrix. 13. Extremal graph theory.	·	
01VAM	Variational Methods	ZK	3
The course is dev	oled to the methods of classical variational calculus - functional extrema by Euler equations, second functional derivative, convexity or n investigation of quadratic functional, generalized solution, Sobolev spaces and variational problem for elliptic PDE's.	nonotonicity. Furthe	r, it contains
02ALT	Algebraic Topology	Z,ZK	4
students with bas	n mathematical and theoretical physics requires one to acquire an ever increasing knowledge of mathematical apparautus. The main g ic methods used in algebraic topology, namely elements of category theory, homototopies, homological algebra and cohomology. An im I language by concepts appearing universally across disciplines like differential geometry and abstract algebra. During excercise sess calculations of introduced mathematical structures.	nportant objective is	s to enhance
02COX	Coxeter Groups	Z	2
The course is an	introduction to the theory of Coxeter groups and their invariant theory. The case of the finite Coxeter groups - the reflection groups are well chamber and length are defined. General theory of the Coxeter groups, the corresponding bilinear forms and the theory of their of the content of th	classification repres	are studied. sent abstrac

generalization of the reflection groups. The study of affine Weyl groups and related objects forms basic example of infinite Coxeter groups. As an introduction to the invariant theory the MacDonald identity and the Weyl identity are presented.

00000454			
02DPMF1	Master Thesis 1	Z	10
The diploma project	t is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the proj regular meetings and discussions.	ect supervisor duri	ng common
02DPMF2	Master Thesis 2	Z	20
	t is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the proj		
	regular meetings and discussions.		
02DSMF	Diploma Seminar	Z	1
•	e seminar, students familiarize themselves with the general principles of publishing and presenting scientific work and the formal req	•	
	econd part is designed as a practical training for the defence of the diploma project. The students give oral presentations of the curre ne work on their projects. Each presentation is followed by a discussion on scientific matters as well as on the possibilities of improvir		
02FG	Physics of graphene described by Dirac equation	7	2
	of crystal. Tight-binding model of graphene and its approximation in terms of Dirac equation. Transport of Dirac fermions in graphene	_	
•	enomena. Bilayer graphene, its description and properties in the external magnetic field. Carbon nanotubes, their classification. Basic	•	
	nanoribbons, boundary conditions and energy. Dirac fermions in curved space, fullerenes. Other Dirac materials.		
02GMF2	Geometric Methods in Physics 2	Z,ZK	5
	elds forms the foundation of contemporary particle physics, namely of the Standard Model. The main goal of this course to to acquaint s		
apparatus required	for its geometric description. We will focus on theory of principal fiber bundles and the interpretation of gauge fields as connection fo All theoretical concepts are demonstrated on particular examples, e.g. frame bundle, Hopf fibration and Yang-Mills field.	rms on principal fic	er bundles.
02GR	Groups and Representations	Z,ZK	3
	ures is to acquaint students with the basic concepts of discrete group theory and their representations. The student will be thoroughly		
of classi	ication of finite groups, decomposition of groups into direct and semidirect products, and with the properties of reducible and irreduci	ble representations	5.
02GSKS	Groups of symmetry of quantum systems	ZK	2
-	erably for the students of Mathematical Physics - is aimed to introduce them to advanced topics connected with applications of group		
_	igner theorem on symmetry operations in quantum physics, the classification of projective representations of Lie groups as well as the	-	ules will be
	t with. The groups important in physics the Euclid, the Poincaré and the Galilei group will be treated by Mackeys method of induced r	·	
02INB	Integrability and beyond nian systems and their integrals of motion. Hamilton-Jacobi equation and separation of variables. Classification of integrable systems	Z with integrals poly	nomial in
7 DStraot. Flamme	momenta. Superintegrability. Perturbative methods in the study of Hamiltonian systems.	with integrals poly	nonna in
02KCH	Quantum Chemistry	Z,ZK	3
Introduction to qu	antum chemistry. Students will acquire theoretical and practical skills to solve basic problems of theoretical quantum chemistry with f		
02KFA	Quantum Physics	Z,ZK	6
-	ure is formulating and developing quantum theory as a physically motivated, but mathematically rigorous theory built upon the analysis		
	separable Hilbert spaces. Previous knowledge of quantum mechanics is an advantage but not a predisposition for the course. The p	-	-
· ·	of the theory and deriving their consequences for model systems, as well as a detailed study of the most commonly used observable focuses on the exactness and proofs of the statements. Some common mistakes resulting from breaking the assumptions of these a		nanics. The
02KO1	Quantum Optics 1	Z,ZK	4
	sical optics, the course shows the construction of a semiclassical Quantum Optics theory of light and light-matter interaction. The ain		=
	ry allowing the qualitative and quantitative description of a broad range of quantum optical phenomena as well as some methods for		-
02KO2	Quantum Optics 2	Z,ZK	4
	etes Quantum Optics 1 by teaching the terminology and computational methods related to the reformulation of Quantum Optics in ph	aca chara It alco	
application areas	continuum modes and dissipative processes. A concise survey of modern research topics in both theoretical and practical parts of	•	
001/TDM4	and the state of t	•	
	applications in further experimental research is also provided.	Quantum Optics as	well as its
02KTPA1 The lecture aims	Quantum Field Theory 1	Quantum Optics as	s well as its
The lecture aims		Quantum Optics as Z,ZK ativistic quantum m	8 sechanics,
The lecture aims	Quantum Field Theory 1 to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relations of the students to both fundamental and applied parts of quantum field theory.	Quantum Optics as Z,ZK attivistic quantum marve as a base for fu	8 sechanics,
The lecture aims	Quantum Field Theory 1 to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relation of scalar and bispinor field, perturbation theory (Feynmans rules) and basics of renormalization. The content of the lecture can se	Quantum Optics as Z,ZK attivistic quantum marve as a base for fu	8 sechanics,
The lecture aims canonical quantiza 02KTPA2 The lecture aims	Quantum Field Theory 1 to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relation of scalar and bispinor field, perturbation theory (Feynmans rules) and basics of renormalization. The content of the lecture can se in fields of exactly solvable models, theory of critical phenomena, molecular chemistry and biochemistry or quantum gravity Quantum Field Theory 2 at introducing the students to the Feynmans functional integral and its applications. The focus is on broadening the knowledge of mo	Z,ZK ativistic quantum m rve as a base for fu Z,ZK dern parts of relati	8 sechanics, urther study 8 vistic and
The lecture aims canonical quantiza 02KTPA2 The lecture aims	Quantum Field Theory 1 to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relation of scalar and bispinor field, perturbation theory (Feynmans rules) and basics of renormalization. The content of the lecture can se in fields of exactly solvable models, theory of critical phenomena, molecular chemistry and biochemistry or quantum gravity. Quantum Field Theory 2 at introducing the students to the Feynmans functional integral and its applications. The focus is on broadening the knowledge of molyantum field theory and statistical physics. The content of the lecture can serve as a base for further study in fields of exactly solvab	Z,ZK ativistic quantum m rve as a base for fu Z,ZK dern parts of relati	8 sechanics, urther study 8 vistic and
The lecture aims canonical quantiza 02KTPA2 The lecture aims non-relativistic	Quantum Field Theory 1 to introduce the students to both fundamental and applied parts of quantum field theory. The focus is in particular on equations of relation of scalar and bispinor field, perturbation theory (Feynmans rules) and basics of renormalization. The content of the lecture can see in fields of exactly solvable models, theory of critical phenomena, molecular chemistry and biochemistry or quantum gravity. Quantum Field Theory 2 at introducing the students to the Feynmans functional integral and its applications. The focus is on broadening the knowledge of molecular field theory and statistical physics. The content of the lecture can serve as a base for further study in fields of exactly solvab phenomena, molecular chemistry and biochemistry or quantum gravity.	Z,ZK ativistic quantum m rve as a base for fu Z,ZK dern parts of relati le models, theory of	8 echanics, urther study 8 vistic and of critical
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02PPKT	Advanced Topics of Quantum Theory	ZK	2
Linear operators in	Hilbert spaces, the uncertainty relations, the canonical commutational relations, the Stone theorem, algebras of observables, the Sc	chrödinger operato	rs. There is
	an overlap with 01KF, contents is modified according to students' requirements.		
02QIC	Quantum Information and Communication	Z,ZK	4
Quantum theory	brought new ideas to the theory of information leading which ultimately lead to the theory of quantum information, computation and	communication. Th	e lecture
introduces the basi	ic concepts of quantum information e.g. quantum algorithms (Shors and Grovers), entanglement, quantum teleportation, quantum cry	yptography and qua	antum error
correction.	It also provides an introduction to modern parts of quantum information, e.g. measurement-based and adiabatic quantum computatio	n and quantum wa	alks.
02QPRGA	Quantum Programming	Z	3
•	irse is to provide the basic skills for programming quantum computers, and to use these skills to develop an understanding of fundam	•	
	uantum algorithms. The classes are combinations of lectures that introduce the essential concepts and tools, and interactive tutorials		
•	Python programming language. Every week the students will be given Jupyter notebooks involving self-study materials and homework		
	ers students from all years and familiarity with quantum mechanics is not necessary. The classes are held entirely online to get the m		٠ ا
	ationally accessible. The quantum SDK Qiskit will be used during the course. Use of own laptops with a quantum SDK installed befor	e the course start i	is required.
02REL1	Relativistic Physics I	Z,ZK	6
Tensor analysis	. Schwarzschild solution of Einstein equations. Black holes and gravitational collapse. Relativistic theory of stellar equilibria and evolu	tion. Linearized the	eory and
	gravitational waves.		
02REL2	Relativistic Physics 2	Z,ZK	6
Lagrangian formali	ism and conservation laws in general relativity. Initial value problem, 3+1 splitting and Gauss-Codazzi equations. Hamiltonian formalis	m in general relativ	vity. Causal
	structure of spacetime. Geometry of timelike and null congruences.		
02RMMF	Solvable Models of Mathematical Physics	Z	2
	Elementary methods for solving nonlinear differential equations occuring in mathematical physics are explained.		
02SKTPE1	Seminar on quantum field theory 1	Z	3
The le	cture aims to introduce the students to advanced topics of quantum field theory. The focus is mainly on quantization with Feynmans f	unctional integral.	
02SKTPE2	Seminar on quantum field theory 2	Z	3
The le	cture aims to introduce the students to advanced topics of quantum field theory. The focus is mainly on quantization with Feynmans f	unctional integral.	
02UST1	Introduction to Strings 1	Z	3
'	The goal of the lecture is to present the basics the (super)string theory	'	
02UST2	Introduction to Strings 2	Z	3
'	The goal of the lecture is to develop the basics the (super)string Theory explained in UST1	. '	
02VPSFA	Selected Topics in Statistical Physics and Thermodynamics	Z,ZK	7
	trates on some advanced topics of statistical mechanics not discussed in the basic course on thermodynamics and statistical physics	. , .	ning density
matrices, the	e behaviours of nonideal gases and its macroscopic description, microscopic description of phase transitions, the role of fluctuations	are addressed in d	letail.
02VUMF1	Research Project 1	Z	6
The research project	ct is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the proj	ect supervisor duri	ng common
	regular meetings and discussions.		
02VUMF2	Research Project 2	KZ	8
The research project	r t is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the proj	ect supervisor duri	ng common
	regular meetings and discussions.		
02ZS	Winter School of Mathematical Physics	Z	1
The aim of the wi	nter school of mathematical physics is to significantly improve presentation skills of the students and their ability to follow specialized	conference preser	ntations in
English. Each stude	ent presents a specialized talk in English on the topic of his/her own research. The goal is to create such suitable conditions that motiva	ite students toward	s a rigorous
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experts from CTU and other universities.

For updated information see http://bilakniha.cvut.cz/en/FF.html
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