Study plan

Name of study plan: Matematická fyzika

Faculty/Institute/Others:
Department: Department of Physics
Branch of study guaranteed by the department: Mathematical Physics
Garantor of the study branch: prof. RNDr. Ladislav Hlavatý, DrSc.
Program of study: Applications of Natural Sciences
Type of study: Follow-up master full-time
Required credits: 86
Elective courses credits: 34
Sum of credits in the plan: 120
Note on the plan:

Name of the block: Compulsory courses of the specialization
Minimal number of credits of the block: 86
The role of the block: PO

Code of the group: NMSMFPP1
Name of the group: NMSMF - povinné předměty 1. ročník
Requirement credits in the group: In this group you have to gain at least 44 credits
Requirement courses in the group: In this group you have to complete at least 8 courses
Credits in the group: 44
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
02GMF2	**Geometric Methods in Physics 2** *Jan Vysoký* ***Jan Vysoký*** *Jiří Tolar (Gar.)*	Z,ZK	5	2+2	L	PO
02GR	**Groups and Representations** *Goce Chadzitaskos Goce Chadzitaskos (Gar.)*	Z,ZK	3	2+1	Z	PO
01KF	**Quantum Physics** *Václav Potoček* ***Michal Jex*** *Václav Potoček (Gar.)*	Z,ZK	6	4+2	L	PO
02KTP1	**Quantum Field Theory 1** *Petr Jizba* ***Václav Zatloukal*** *Petr Jizba (Gar.)*	Z,ZK	9	4+2	Z	PO
02LIAG	**Lie Algebras and Lie Groups** *Libor Šnobl Libor Šnobl (Gar.)*	Z,ZK	6	3+2	L	PO
02VUMF1	**Research Project 1** *Ladislav Hlavatý (Gar.)*	Z	6	6	Z,L	PO
02VUMF2	**Research Project 2** *Jiří Tolar (Gar.)*	KZ	8	8	L,Z	PO
02ZS	**Winter School of Mathematical Physics** *Goce Chadzitaskos (Gar.)*	Z	1	1týd.	Z	PO

Characteristics of the courses of this group of Study Plan: Code=NMSMFPP1 Name=NMSMF - povinné předměty 1. ročník

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 mathematical apparautus 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 lecture course is dedicated to the introduction to the group theory and group representations including their applications in physics.			
01KF	Quantum Physics	Z,ZK	6
Basic quantum theory presented via rigorous mathematical methods.			
02KTP1	Quantum Field Theory 1	Z,ZK	9
The equations of relativistic quantum mechanics. The Lagrange formalism in the classical field theory. Introduction to quantum field theory.			
02LIAG	Lie Algebras and Lie Groups	Z,ZK	6
Definitions and properties of Lie groups and Lie algebras. Different types of Lie algebras, root systems and classification of complex simple Lie algebras. Introduction to theory of representations.			
02VUMF1	Research Project 1	Z	6
Research project on a chosen subject supervised by an adviser.			
02VUMF2	Research Project 2	KZ	8
Research project on a chosen subject supervised by an adviser.			

02ZS	Winter School of Mathematical Physics	Z	1
Research project on a chosen subject supervised by an adviser.			

Code of the group: NMSMFPP2
Name of the group: NMSMF - povinné předměty 2. ročník
Requirement credits in the group: In this group you have to gain at least 42 credits
Requirement courses in the group: In this group you have to complete at least 4 courses
Credits in the group: 42
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
02DPMF1	**Master Thesis 1** ***David Krejčiřík*** *Ladislav Hlavatý (Gar.)*	Z	10	10	Z,L	PO
02DPMF2	**Master Thesis 2** ***David Krejčiřík*** *Ladislav Hlavatý (Gar.)*	Z	20	20	L,Z	PO
02KOHOM	**Cohomological Methods in Theoretical Physics** *Jan Vysoký* ***Jan Vysoký*** *Jiří Tolar (Gar.)*	ZK	5	2		PO
02VPSF	**Selected Topics in Statistical Physics and Thermodynamics** *Jaroslav Novotný, Igor Jex Igor Jex (Gar.)*	Z,ZK	7	2+2	Z	PO

Characteristics of the courses of this group of Study Plan: Code=NMSMFPP2 Name=NMSMF - povinné předměty 2. ročník

02DPMF1	Master Thesis 1	Z	10
Master's thesis on a chosen subject supervised by an adviser.			
02DPMF2	Master Thesis 2	Z	20
Master's thesis on a chosen subject supervised by an adviser.			
02KOHOM	Cohomological Methods in Theoretical Physics	ZK	5
Singular homology, the de Rham cohomology. The Čech cohomology and gauge fields. The Chevalley cohomology and projective representations in quantum theory. Deformations of associative and Lie algebras.			
02VPSF	Selected Topics in Statistical Physics and Thermodynamics	Z,ZK	7
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: NMSMFVP
Name of the group: NMSMF - volitelné předměty
Requirement credits in the group:
Requirement courses in the group:
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
01ASY	**Asymptotical Methods** *Jiří Mikyška* ***Jiří Mikyška*** *Jiří Mikyška (Gar.)*	Z,ZK	3	2+1	Z	V
02COX	**Coxeter Groups** *Jiří Hrivnák* ***Jiří Hrivnák*** *Jiří Hrivnák (Gar.)*	Z	2	2+0		V
01FA3	**Functional Analysis 3** *Pavel Šťovíček* ***Pavel Šťovíček*** *Pavel Šťovíček (Gar.)*	Z,ZK	3	2+1	Z	V
02SPEC	**Geometrical Aspects of Spectral Theory** *David Krejčiřík* ***David Krejčiřík*** *David Krejčiřík (Gar.)*	ZK	2	2+0	L	V
02KIK	**Quantum Information and Communication** *Aurél Gábris* ***Aurél Gábris*** *Igor Jex (Gar.)*	Z	2	2+0	Z	V
02KTP2	**Quantum Field Theory 2** *Petr Jizba, Martin Štefaňák* ***Václav Zatloukal*** *Petr Jizba (Gar.)*	Z,ZK	6	4+2	L	V
01KVGR1	**Quantum Groups 1** *Čestmír Burdík (Gar.)*	Z	2	2+0	Z	V
02KVK1	**Quantum Circle 1** *Pavel Exner (Gar.)*	Z	2	0+2	Z	V
02KVK2	**Quantum Circle 2** *Pavel Exner (Gar.)*	Z	2	0+2	L	V

01MMNS	**Mathematical Modelling of Non-linear Systems** *Michal Beneš Michal Beneš (Gar.)*	ZK	3	2	Z	v
02NSY	**Nonequilibrium Systems** *Igor Jex Igor Jex (Gar.)*	Z	2	2+0	L	v
02OKS	**Open Quantum Systems** *Jaroslav Novotný Jaroslav Novotný (Gar.)*	Z	2	2+0		v
02PPKT	**Advanced Topics of Quantum Theory** *Pavel Exner Pavel Exner (Gar.)*	ZK	2	2+0	L	v
02REL1	**Relativistic Physics I** *Oldřich Semerák, Jiří Bičák Jiří Bičák (Gar.)*	Z,ZK	6	4+2	Z	v
02REL2	**Relativistic Physics 2** *Oldřich Semerák, Jiří Bičák Jiří Bičák (Gar.)*	Z,ZK	6	4+2	L	v
01NAH	**Theory of Random Processes** *Jan Vybíral Jan Vybíral (Gar.)*	ZK	3	3+0	Z	v
01VAM	**Variational Methods** *Michal Beneš Michal Beneš (Gar.)*	ZK	3	2	Z	v
01ZPB1	**Introduction to Computer Security 1** *Petr Vokáč **Petr Vokáč** Petr Vokáč (Gar.)*	Z	2	1+1		v
01ZPB2	**Introduction to Computer Security 2** *Petr Vokáč **Petr Vokáč** Petr Vokáč (Gar.)*	Z	2	1+1		v
01ZTG	**Introduction to Graph Theory** *Petr Ambrož **Petr Ambrož** Petr Ambrož (Gar.)*	ZK	4	4+0		v
02UST1	**Introduction to Strings 1** *Ladislav Hlavatý Ladislav Hlavatý (Gar.)*	Z	3	2+1	Z	v
02UST2	**Introduction to Strings 2** *Ladislav Hlavatý Ladislav Hlavatý (Gar.)*	Z	3	2+1	L	v
02RMMF	**Solvable Models of Mathematical Physics** *Ladislav Hlavatý Ladislav Hlavatý (Gar.)*	Z	2	2+0	L	v

Characteristics of the courses of this group of Study Plan: Code=NMSMFVP Name=NMSMF - volitelné předměty

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 introduction to the theory of Coxeter groups and their invariant theory. The case of the finite Coxeter groups - the reflection groups and their properties are studied. The notions of the Weyl chamber and length are defined. General theory of the Coxeter groups, the corresponding bilinear forms and the theory of their classification represent abstract 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.

01FA3	Functional Analysis 3	Z,ZK	3

Advanced parts of functional analysis needed for modern quantum theory.

02SPEC	Geometrical Aspects of Spectral Theory	ZK	2

Spectral theory is an extremely rich field which has found its application in many areas of physics and mathematics. One of the reason which makes it so attractive on the formal level is that it provides a unifying framework for problems in various branches of mathematics, for example partial differential equations, calculus of variations, geometry, stochastic analysis, etc. The goal of the lecture is to acquaint the students with spectral methods in the theory of linear differential operators coming both from modern as well as classical physics, with a special emphasis put on geometrically induced spectral properties. We give an overview of both classical results and recent developments in the field, and we wish to always do it by providing a physical interpretation of the mathematical theorems.

02KIK	Quantum Information and Communication	Z	2

Quantum theory brought new ideas to the theory of information leading which ultimately lead to the theory of quantum information, computation and communication. The lecture introduces the basic concepts of quantum information e.g. quantum algorithms (Shor's and Grover's), entanglement, quantum teleportation, quantum cryptography and quantum error correction. It also provides an introduction to modern parts of quantum information, e.g. measurement-based and adiabatic quantum computation and quantum walks.

02KTP2	Quantum Field Theory 2	Z,ZK	6

Lagrange formalism in classical field theory. Canonical quantization of free fields. Interactions of quantized fields. Perturbation expansion of the S-matrix. Feynman diagrams. Quantum electrodynamics. Regularization and renormalization.

01KVGR1	Quantum Groups 1	Z	2

Quantum Algebra was originated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in order to solve integrable models. They have many applications in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and the string theory.

02KVK1	Quantum Circle 1	Z	2

Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.

02KVK2	Quantum Circle 2	Z	2

Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.

01MMNS	Mathematical Modelling of Non-linear Systems	ZK	3

The course consists of basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary differential equations, and description of bifurcations and chaos. Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systems.

02NSY	Nonequilibrium Systems	Z	2

The study of instabilities in physics enables a unified description and understanding of many processes and effects in physical, chemical and living systems. The course focuses on the mathematical desription methods and on processes of selforganization in systems like the laser, morphogenesis (chemical reactions), changes in societies.

02OKS	Open Quantum Systems	Z	2

Quantum description of composite subsystems and their subsystems, density operator. Pure and mixed states, entropy. Quantum correlations, entanglement, its basic properties and possible applications. Introduction to theory of generalized quantum measurement, positive operator-valued measure, physical realizations. Quantum operations, general description of state changes, superoperator theoretical framework, examples of quantum operations. Markovian quantum master equation, quantum dynamical semigroups. Basic models for description of decoherence and thermalization.

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 Schrödinger operators. There is an overlap with 01KF, contents is modified according to students´ requirements.

02REL1	Relativistic Physics I	Z,ZK	6
Tensor analysis. Curvature and Einstein gravitational law. Schwarzschild solution of Einstein equations. Black holes and gravitational collapse.			
02REL2	Relativistic Physics 2	Z,ZK	6
Black holes and gravitational collapse. Astrophysics of black holes. General relativity in other branches of physics and astrophysics. Linearised theory of gravitation, gravitational waves.			
01NAH	Theory of Random Processes	ZK	3
The course is devoted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and sequences both weakly and strongly stationary ones.			
01VAM	Variational Methods	ZK	3
The course is devoted to the methods of classical variational calculus - functional extrema by Euler equations, second functional derivative, convexity or monotonicity. Further, it contains investigation of quadratic functional, generalized solution, Sobolev spaces and variational problem for elliptic PDE's.			
01ZPB1	Introduction to Computer Security 1	Z	2
01ZPB2	Introduction to Computer Security 2	Z	2
01ZTG	Introduction to Graph Theory	ZK	4
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			
02RMMF	Solvable Models of Mathematical Physics	Z	2
Elementary methods for solving nonlinear differential equations occuring in mathematical physics are explained.			

List of courses of this pass:

Code	Name of the course	Completion	Credits
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.			
01FA3	Functional Analysis 3	Z,ZK	3
Advanced parts of functional analysis needed for modern quantum theory.			
01KF	Quantum Physics	Z,ZK	6
Basic quantum theory presented via rigorous mathematical methods.			
01KVGR1	Quantum Groups 1	Z	2
Quantum Algebra was originated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in order to solve integrable models. They have many applications in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and the string theory.			
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The course consists of basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary differential equations, and description of bifurcations and chaos. Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systems.			
01NAH	Theory of Random Processes	ZK	3
The course is devoted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and sequences both weakly and strongly stationary ones.			
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The course is devoted to the methods of classical variational calculus - functional extrema by Euler equations, second functional derivative, convexity or monotonicity. Further, it contains investigation of quadratic functional, generalized solution, Sobolev spaces and variational problem for elliptic PDE's.			
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02DPMF1	Master Thesis 1	Z	10
Master's thesis on a chosen subject supervised by an adviser.			
02DPMF2	Master Thesis 2	Z	20
Master's thesis on a chosen subject supervised by an adviser.			
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 mathematical apparautus 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.			
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02KOHOM	Cohomological Methods in Theoretical Physics	ZK	5
Singular homology, the de Rham cohomology. The Čech cohomology and gauge fields. The Chevalley cohomology and projective representations in quantum theory. Deformations of associative and Lie algebras.			
02KTP1	Quantum Field Theory 1	Z,ZK	9
The equations of relativistic quantum mechanics. The Lagrange formalism in the classical field theory. Introduction to quantum field theory.			
02KTP2	Quantum Field Theory 2	Z,ZK	6
Lagrange formalism in classical field theory. Canonical quantization of free fields. Interactions of quantized fields. Perturbation expansion of the S-matrix. Feynman diagrams. Quantum electrodynamics. Regularization and renormalization.			
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Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
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Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
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Definitions and properties of Lie groups and Lie algebras. Different types of Lie algebras, root systems and classification of complex simple Lie algebras. Introduction to theory of representations.			
02NSY	Nonequilibrium Systems	Z	2
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Quantum description of composite subsystems and their subsystems, density operator. Pure and mixed states, entropy. Quantum correlations, entanglement, its basic properties and possible applications. Introduction to theory of generalized quantum measurement, positive operator-valued measure, physical realizations. Quantum operations, general description of state changes, superoperator theoretical framework, examples of quantum operations. Markovian quantum master equation, quantum dynamical semigroups. Basic models for description of decoherence and thermalization.			
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 Schrödinger operators. There is an overlap with 01KF, contents is modified according to students´ requirements.			
02REL1	Relativistic Physics I	Z,ZK	6
Tensor analysis. Curvature and Einstein gravitational law. Schwarzschild solution of Einstein equations. Black holes and gravitational collapse.			
02REL2	Relativistic Physics 2	Z,ZK	6
Black holes and gravitational collapse. Astrophysics of black holes. General relativity in other branches of physics and astrophysics. Linearised theory of gravitation, gravitational waves.			
02RMMF	Solvable Models of Mathematical Physics	Z	2
Elementary methods for solving nonlinear differential equations occuring in mathematical physics are explained.			
02SPEC	Geometrical Aspects of Spectral Theory	ZK	2
Spectral theory is an extremely rich field which has found its application in many areas of physics and mathematics. One of the reason which makes it so attractive on the formal level is that it provides a unifying framework for problems in various branches of mathematics, for example partial differential equations, calculus of variations, geometry, stochastic analysis, etc. The goal of the lecture is to acquaint the students with spectral methods in the theory of linear differential operators coming both from modern as well as classical physics, with a special emphasis put on geometrically induced spectral properties. We give an overview of both classical results and recent developments in the field, and we wish to always do it by providing a physical interpretation of the mathematical theorems.			
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			
02VPSF	Selected Topics in Statistical Physics and Thermodynamics	Z,ZK	7
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.			
02VUMF1	Research Project 1	Z	6
Research project on a chosen subject supervised by an adviser.			
02VUMF2	Research Project 2	KZ	8
Research project on a chosen subject supervised by an adviser.			
02ZS	Winter School of Mathematical Physics	Z	1
Research project on a chosen subject supervised by an adviser.			

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