TOMSK STATE PEDAGOGICAL UNIVERSITY
(TSPU)

The degree program of higher education

011200 Physics
Master program in Theoretical Physics

Qualification (degree) – Master in Physics

2013

1. Requirements for Graduate Degrees

The graduate should have the following Competences, Knowledge and Skills:

ability to demonstrate in-depth knowledge in mathematics and natural sciences;
ability to demonstrate in-depth knowledge in the humanities and economic sciences;
ability to independently acquire new knowledge and skills;
ability to use advanced knowledge of legal and ethical standards in evaluating the impact of their work;
ability to generate new ideas (creativity);
ability to refine and develop his or her intellectual level;
ability to adapt to the changing scientific and research-and-production profile of their professional activities;
ability to communicate in scientific, industrial and social and public areas;
ability to apply active social mobility;
ability to use basic knowledge and information management skills to address research professional tasks,
ability to freely possess fundamental topics in physics, is required.

ability to use knowledge of modern problems of Physics in its research and development activities;
ability to set specific tasks of scientific research in the field;
ability to practice the skills of drafting and processing of scientific and technical documentation, scientific reports, reviews, and reports;
ability to freely possess professional knowledge for the analysis and synthesis of the physical;
ability to organize and plan the physical research;
ability to organize a working group to resolve professional tasks;
ability to manage research activities of junior high school students and high school students in physics.

2. Curriculum

Tomsk State Pedagogical University
(TSPU)

Approved by Scientific Council of TSPU
"____" ________________ 20 _r.
Chairman of Scientific Council, rector
___________________ V.V. Obukhov

Curriculum

Title conferred: Master
Length of programme: 2 years
Mode of study: full time
Access Requirements: higher education

Name of the qualification 011200.68 Physics
Master degree program: Theoretical and Mathematical Physics

I. Schedule of the learning

Year	September				October				November				December					January				February			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
I																P	P	P	E	E	E	V	V		
II	P	P	P	P	P	P	P	P	P	P								E	V	V	R	R	R	R	R

Year	March					April				May				June					July				August				
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
I														P	P	P	E	E	E	V	V	V	V	V	V	V	V
II	R	R	R	R	R	R	F	F	F	F	F	F	F	F	F	F	F	F	F	V	V	V	V	V	V	V	V

Notations:
E – examinations, V – vacations, P – Practicum, R – research,
F - Final Examinations

II. Time budget in weeks

Theoretical study	Examinations	Practicum and Research	Final examination	Vacations	Total	Year of study
29	4	10	0	9	52	I
12	3	10	20	7	52	II
41	**7**	**20**	**20**	**16**	**104**	**Total**

III. Curriculum

Code	Course	Credit units	Workload, hours						Hours per week			
			Total	Contact hours				Home Work	1[st] year		2[nd] year	
				Total	lectures	labs	seminars		1	2	3	4
									15	15	7	0
1	2	5	6	7	8	9	10	11	12	13	14	15
M.1	**General Module**	**32**	**1152**	**284**	**105**	**0**	**179**	**868**				
M.1.00	***Basic part***	**8**	**288**	**74**	**15**	**0**	**59**	**214**				
	Philosophy of natural sciences*	4	144	30	15	0	15	114	1//1			
	Physics Laboratory	4	144	44	0	0	44	100	//1	//1	//2	
M.1.B.00	***Variable part***	**24**	**864**	**210**	**90**	**0**	**120**	**654**				
	Courses defined by department	***20***	***720***	***150***	***60***	***0***	***90***	***570***				
	Foreign language	6	216	60	0	0	60	156	//2	//2		
	Lie group theory	6	216	45	30	0	15	171	2//1			
	Advanced Quantum Mechanics	8	288	45	30	0	15	243	2//1			
	Optional courses	***4***	***144***	***60***	***30***	***0***	***30***	***84***				
	Differential Geometry/Modern Electrodynamics	2	72	30	15	0	15	42		1//1		
	Hamiltonian Systems with Constrains / Mathematical Methods of (	2	72	30	15	0	15	42		1//1		
M.2	**Professional Module**	**28**	**1008**	**232**	**116**	**0**	**116**	**776**				
M.2.00	***Basic part***	**8**	**288**	**60**	**30**	**0**	**30**	**228**				
	Modern Problems in Physics	4	144	30	15	0	15	114	1//1			
	History and Methodology of Physics	4	144	30	15	0	15	114		1//1		
M.2.B.00	***Variable part***	**20**	**720**	**172**	**86**	**0**	**86**	**548**				
	Courses defined by department	***14***	***504***	***116***	***58***	***0***	***58***	***388***				
	Classical Fields	4	144	58	29	0	29	86		1//1	2//2	
	Quantum Field Theory	3	108	28	14	0	14	80			2//2	
	General Relativity	3	108	30	15	0	15	78		1//1		
	Supersymmetric Field Theory	2	72	0	0	0	0	72				1//1
	String Theory	2	72	0	0	0	0	72				2//2
	Optional courses	***6***	***216***	***56***	***28***	***0***	***28***	***160***				
	Cosmology	3	108	28	14	0	14	80			2//2	
	Quantum Gauge Theory / Quantum Theory of Radiation	3	108	28	14	0	14	80			2//2	
M.3	**Practicum and Research**	**40**	**1440**	**0**	**0**	**0**	**0**	**1440**				
M.4	**Final Examinations**	**20**	**720**	**0**	**0**	**0**	**0**	**720**				
	Total workload	**120**	**4320**	**516**	**221**	**0**	**295**	**3804**				
									13	13	18	6
	Average hours per week								165	195	126	0
	13,95				10				3	3	3	1
					9				2	4	2	1

* - lectures/ labs/seminars

3. Syllabus of the courses

Philosophy of natural sciences

Formation of the philosophy of science as a way of learning and development in the world, major sections of contemporary philosophical knowledge, philosophical problems and methods of their study; Mastering the basic principles and techniques of philosophical cognition; Introduction to the range of philosophical issues related to the future professional activities.

Physics Laboratory

The purposes of Lab course are to give students hands-on experience with some of the experimental basis of modern physics and, in the process, to deepen their understanding of the relations between experiment and theory.

Foreign language

Foreign language studies is aimed at the comprehensive development of communicative, cognitive, information, socio-cultural, professional, and general cultural competence of students.

Lie group theory

The goal is to acquire familiarity with the basic formalism and results concerning unitary representations of Lie groups, and to apply these to the study of discrete subgroups, especially lattices, in Lie groups. basic manifold theory, vector fields, tangent spaces leading to the Exponential mapping for an affine connection. The exponential mapping for a Lie group emerges as a special case. The relationship between Lie subgroups and Lie subalgebras via the exponential mapping will be developed in detail. Lie's three fundamental theorems relating all finite-dimensional Lie algebras with local Lie groups will be proved via Maurer-Cartan forms and the global version by means of the Levi-decomposition. We conclude with a study of invariant differential forms on Lie groups and coset spaces, ending with some results about cohomology of Lie groups.

Textbooks

1. Howard Georgi, Lie Algebras in Particle Physics, ABP, 1999.
2. P. Ramond, Group Theory, Cambridge Univ.Press., 2010.
3. Wu-Ki Tung, Group Teory in Physics, World Scientific, 1999.

Advanced Quantum Mechanics

Topics covered include: general formalism of quantum mechanics, time-dependent perturbation theory and applications to radiation, quantization of EM radiation field, adiabatic theorem and Berry's phase, symmetries in QM, many-particle systems, second quantization, scattering theory, relativistic quantum mechanics.

Textbooks

1. J.J. Sakurai, Modern Quantum Mechanics. Revised Edition. Addison-Wesley publishers. 2010.
2. B.H. Bransden, C.J. Joachain, Quantum Mechanics, Pearson, Prentice Hall, 2000.

Differential Geometry

This course is an introduction to differential geometry. Students should have a good knowledge of multivariable calculus and linear algebra, as well as tolerance for a definition–theorem–proof style of exposition. The course itself is mathematically rigorous, but still emphasizes concrete aspects of Riemann geometry.

Textbooks

1. T. Frankel, The Geometry of Physics, Cambridge Univ. Press., 1997.
2. M. Nakahara, Geometry, Topology and Physics, IOP Publ., 1990.

Modern Electrodynamics

The course covers the basic principles of electromagnetism: experimental basis, electrostatics, magnetic fields of steady currents, motional e.m.f. and electromagnetic induction, Maxwell's equations, propagation and radiation of electromagnetic waves, electric and magnetic properties of matter, and conservation laws. This is a graduate level subject which uses appropriate mathematics but whose emphasis is on physical phenomena and principles.

Textbooks

1. Schwinger, Julian, L. L. DeRaad Jr., K. A. Milton, W-Y Tsai. Classical Electrodynamics. Reading, Massachusetts: Perseus Book Group, 1998. ISBN: 9780738200569.
2. Jackson, J. D. Classical Electrodynamics. New York: Wiley, 1998. ISBN: 9780471309321.
3. Landau, L. D., and E. M. Lifshitz. Classical Theory of Fields. Oxford: Pergamon Press, 2012. ISBN: 9780080181769.

Hamiltonian Systems with Constrains

Hamiltonian dynamics is one of the cornerstones of advanced education in physics and applied mathematics. The course covers all the topics necessary for a graduate-level course in dynamics based on Hamiltonian methods. Students are introduced to the impressive advances in the field during the second half of the twentieth-century, including KAM theory and deterministic chaos. Essential to these developments are some exciting ideas from modern mathematics, which are introduced carefully and selectively.

Textbooks

1. D.M. Girman, I.V. Tyutin, Quantization of Fields with Constraints, Springer, 1990.
2. M. Henneaux, C. Teitelboim, Quantization of Gauge Systems, Princeton Univ. Press., 1992.

Mathematical Methods of Classical Mechanics

The course is devoted to the mathematical apparatus of classical mechanics from the beginning, examining all the basic problems in dynamics, including the theory of oscillations, the theory of rigid body motion, and the Hamiltonian formalism.

Textbooks

1. Arnol'd, V.I. Mathematical Methods of Classical Mechanics, Springer, 1989.

Modern Problems in Physics

This course provides an introduction to classical dynamics, waves, special relativity and quantum physics. It serves both as a preparation for further study in physics-based degree programmes, and as a stand-alone course for students of other disciplines, including mathematics, chemistry, computer science and engineering. The course consists of lectures to present new material, and workshops to develop understanding, familiarity and fluency.

Textbooks

1. Problems and Solutions on Mechanics, ed. by Young-Kuo Lim, World Scientific, 2005.
2. Problems and Solutions on Electromagnetism, ed. by Young-Kuo Lim, World Scientific, 2005
3. Problems and Solutions on Quantum Mechanics, ed. by Young-Kuo Lim, World Scientific, 2005.

History and Methodology of Physics

In the history of science, only three hundred years separate the discoveries of Galileo and Albert Einstein. Recent science has brought us relativity theory, quantum mechanics, and elementary particle physics-in a radical and mercurial departure from earlier developments. In this course the interactions of mathematics and physics with logic and philosophy in the rapidly changing environment of modern science is considered.

Textbooks

1. Colodny, Robert G. From Quarks to Quasars: Philosophical Problems of Modern Physics. University of Pittsburgh Press, 1986.

Classical Fields

This course presents gravitation and gauge fields as interrelated topics with a common physical and mathematical foundation, such as gauge theory of gravitation and other fields, giving emphasis to the physicist's point of view. About half of the material is devoted to Einstein's general relativity theory, and the rest to gauge fields that naturally blend well with gravitation, including spinor formulation, classification of SU(2) gauge fields and null-tetrad formulation of the Yang-Mills field in the presence of gravitation. The text includes an introduction to the physical foundation of the theory of gravitation. It also provides the mathematical theory of the geometry of curved space-times needed to describe Einstein's general relativity theory.

Textbooks

1. M. Carmeli, Classical Fields, World Scientific, 2002.

2. V.A. Rubakov, Classical Theory of Gauge Fields, Princeton Univ. Press., 2002.

Quantum Field Theory

Quantum Field Theory, designed for mathematicians, is a rigorous introduction to perturbative quantum field theory, using the language of functional integrals. It covers the basics of classical field theory, free quantum theories and Feynman diagrams. The goal is to discuss, using mathematical language, a number of basic notions and results of QFT that are necessary to understand talks and papers in QFT and String Theory.

Textbooks

1. M. Peskin, D.. Schroeder, Introduction to Quantum Field Theory, Addison-Wesley, 2005.

2. S. Weinberg, The Quantum Theory of Fields, Volumes I and II, Cambridge Univ. Press. 1996.

3. Problems of Modern Theoretical Physics. Ed. V. Epp. Tomsk State Pedagogical University Press, 2008.

General Relativity

This course covers the basic principles of Einstein's general theory of relativity, differential geometry, experimental tests of general relativity, black holes, and cosmology.

Textbooks

1. Carroll, Sean. An Introduction to General Relativity: Spacetime and Geometry. San Francisco, CA: Addison Wesley, 2009. ISBN: 9780805387322.

2. Misner, Charles W., Kip S. Thorne, and John Archibald Wheeler. Gravitation. San Francisco, CA: W.H. Freeman, 1973. ISBN: 9780716703440.

3. Weinberg, Steven. Gravitation and Cosmology. New York, NY: Wiley, 1972. ISBN: 9780471925675.

Supersymmetric Field Theory

SUSY algebras and their particle representations; Weyl and Majorana spinors; Lagrangians of basic four-dimensional SUSY theories, both rigid SUSY and supergravity; supermultiplets of fields and superspace methods; renormalization properties, and the non-renormalization theorem; spontaneous breakdown of SUSY; and phenomenological SUSY theories. Some prior knowledge of Noether's theorem, derivation and use of Feynman rules, l-loop renormalization, and gauge theories is essential.

Textbooks

1. Buchbinder, I. L., Kuzenko, S. M. Introduction to Supersymmetric Field Theory. Chapman and Hall/CRC; 2 edition, 2010.

2. Buchbinder, I. L. Elements of Supersymmetric Field Theory. Tomsk State Pedagogical University Press, 2010.

3. Problems of Modern Theoretical Physics. Ed. V. Epp. Tomsk State Pedagogical University Press, 2008.

String Theory

This will be a one-semester class about string models and their applications.

Texbooks

1. Becker, Katrin, Melanie Becker, and John H. Schwarz. String Theory and M-Theory: A Modern Introduction. Cambridge, UK: Cambridge University Press, 2007. ISBN: 9780521860697.

2. Polchinski, Joseph Gerard. String Theory. Vol. 1, An Introduction to the Bosonic String. Cambridge Monographs on Mathematical Physics. Cambridge, UK: Cambridge University Press, 2005. ISBN: 9780521672276.

5. String Theory. Vol. 2, Superstring Theory and Beyond. Cambridge Monographs on Mathematical Physics. Cambridge, UK: Cambridge University Press, 2005. ISBN: 9780521672283.

6. Green, M., John H. Schwarz, and E. Witten. Superstring Theory. Volumes 1 and 2, Cambridge Univ.Press., 1988.

Cosmology

This course provides an overview of astrophysical cosmology with emphasis on the Cosmic Microwave Background (CMB) radiation, galaxies and related phenomena at high redshift, and cosmic structure formation. Additional topics include cosmic inflation, nucleosynthesis and baryosynthesis, quasar (QSO) absorption lines, and gamma-ray bursts. Some background in general relativity is assumed.

Textbooks

1. V. Mukhanov, Physical Foundations of Codsmology, Cambridhe Univ.Press., 2005.

2. S. Weinberg, Cosmology, Oxford Univ. Press., 2008.

3. The Problems of Modern Cosmology. Ed. P.M. Lavrov. Tomsk State Pedagogical University Press, 2009.

Quantum Gauge Theory

Textbooks

1. Peskin, M., and D. Schroeder. An Introduction to Quantum Field Theory. Boulder, Colorado: Westview Press, 1 June 1995. ISBN: 9780201503975.

2. Cheng, Ta-Pei, and Ling-Fong Li. Gauge Theory of Elementary Particle Physics. Clarendon: Oxford University Press, 1984. ISBN: 9780198519560.

3. Aitchison, I., and A. Hey. Gauge Theories in Particle Physics. UK: Oxford University Press, 1 September 1988. ISBN: 9780198519614.

4. Geyer, B., Lavrov, P.M. Covariant Quantizations of Gauge Theories. Tomsk State Pedagogical University Press, 2009.

Quantum Theory of Radiation

Starting from the foundation of quantum mechanics and its applications in simple discrete systems, the course develops the basic principles of interaction of electromagnetic radiation with matter.

Textbooks

1. Heitler, W. The Quantum Theory of Radiation: Third Edition (Dover Books on Physics), 2012.
2. Le Bellac, Michel. Quantum Physics. Cambridge University Press, 2012. ISBN: 9781107602762.