Appendix to the Agreement on the Dual-Degree Program between Shanghai Jiaotong University (Department of Mathematics) and University of Konstanz (Department of Mathematics and Statistics)

Course Description for the Master Course in Mathematics

Shanghai Jiaotong University - September 2007

No.	Course Name	Credit	Description
1	Basic Algebra	4	This course is designed for graduate students who work in all branches in mathematics. Some special materials which only needed for algebraists are not included in this course. The main contents are Galois theory, modules on rings, representations of groups and character theory, categories, and homological algebra. Since there are special courses devoted to commutative algebra and algebraic geometry, these parts are not included in the present course.
2	Real and Complex Analysis	4	This course covers some classical contents about real analysis and complex analysis in which the basic techniques and theorems of analysis are presented in such a way that the intimate connections between its various branches are strongly emphasized. The traditionally separate subjects of real analysis and complex analyses are united. It introduces Banach space techniques; complex measures, including some results of Radon-Nikodym Theorem etc; differentiation, including derivatives of complex measures, fundamental theorem of calculus, etc; maximum modulus principle; approximation by rational functions, including Rung's theorem and Mittag-Leffler theorem; conformal mapping; zeros of holomorphic functions, including Jensen's theorem, Blaschke products and Muntz-Szasz theorem; analytic continuation; Hp spaces; holomorphic Fourier transforms, etc. The fundamental theory and new techniques on real analysis and complex analyses are both addressed.

3	Differentialbe Manifolds and Differential Geometry	4	At the most basic level, this course gives an introduction to differentiable manifolds, exterior differentiation and Riemannian manifolds. In differentiable manifolds, one studies definition of differential manifolds, tangent space, Embedding theorem and partitions of unity. In exterior differentiation, one studies exterior algebra, tangent vector fields, one-parameter groups action on a manifold, Frobenius theorem, exterior differential form, integration on manifolds and Stokes theorem. In Riemannian manifolds, one studies Riemannian metric, covariant derivative, Riemannian connection, basic properties of the Riemann curvature tensor. This course should help student master definitions and basic peoperties of differentiable and Riemannian manifolds, increase his ability from parts to a whole. Furthermore,this course is benefitial for student to study differential topology, Lie group and Nonlinear Analysis.
4	Algebraic Topology	3	This course is an introduction to basic homology and cohomology theory. A rough outline is as follows: Basic ideas of category theory, Simplicial and singular homology, Computations and applications of homology, Axioms for homology, Cohomology group, Cup products, Poincaré duality.
5	Measure and Probability theory	3	This subject assumes to be a basic theory course of random theory. It is an introductory coures emphasizing measure theory and probability theory. It covers two topics. The first topic which called measure theory includes category of sets,probability measure, and integral. The second topic is probability theory. It includes probability distributions, stochastic variables, expected valures, independent, all different type concepts of convergence, the cetral limit theorem and random series, characteristic function, random walk principlesot and conditional probability, Markov chains, and theory of martingales.
6	Functional Analysis and Sobolev Space	3	This course covers linear functional analysis, which include basic operator theoty, Riesz representative theorem and basic spectrum theory. Moreover, we will stress on the theory of Schwartz distribution (or generalised function theory), and then we will deal with the celebrating theory which we call Sobolev space. Because of the importance of Sobolev space and its continuous impact on modern mathematics, we will also select some basic ingredient in some fields such as variational theory and partial differential equation for application of this course. This course will be chosen carefully to get its basic, broadness and challenge, and also it will be updated and forefront.

7	Numerical Methods for Partial Differential Equations	3	This course covers various fields about numerical methods for linear and nonlinear PDEs, including the history and future of them, difference methods, finite elements methods, spectral methods, etc. Where several methods for solving a problem are presented, comparisons of their applicability and limitations are offered. Each comparison is based on operation counts, theoretical properties such as convergence rates, and, more importantly, the intrinsic numerical properties that account for the reliability or unreliability of an algorithm.
8	Combinatorics	3	The course of Combinatorics is a basic course for graduate students with majoring in discrete Mathematics. The course aims to learn fundamental principles and methods and understand its up-to date information. The contents contain the Pigeonhole principle, generating permutations and combinatorics, the binomial coefficients, the inclusion-exclusion principle and its applications, recurrence relations and generating fuctions, special counting sequences, Polya counting.
9	Lie group and Lie Algebra	3	The purpose of this course is to provide an introduction to Lie groups and Lie algebras. This course is divided into four parts: (I) topological groups and differential geometry, (II) Lie group, (III) the structure of compact Lie groups and (VI) the automorphism groups and representation theory of compact Lie groups. It is assumed that the reader has a good knowledge of linear algebra and some basic knowledge of abstract algebra, topology and differential manifold.
10	Basic Number Theory	3	This course covers basic knowlegment in number theory, including divisibity,diophantine equations, congruence, quadratic residues, the distribution of primes, arithmetic function, primitive root and index, transcend of e and /pi, etc. Apart from the fundamental and general introduction on numer theory are introduced, the advanced fields and the future in number theory are also addressed.
11	Ordinary Differential Equations	3	This course is an introduction to the basic properties of differential equations that are needed to approach the modern theory of (nonlinear) dynamical systems. It contains existence theory, flows and Poincare map, invariant manifolds, linearization and Floquet theory, limit sets and Poincare-Bendixson theory, phase plane analysis, and stability. The course also includes some realistic applications, such as Euler-Lagrange equation, the inverted Pendulum,etc.
12	Partial Differential Equations	3	This course concerns the theory of linear partial differential equations. It contains a review on Sobolev spaces, the existence and regularity of weak solutions to second-order elliptic equations, maximum principles for elliptic problems, eigenvalue problems of elliptic operators, the existence and regularity of weak solutions to initial (-boundary) value problems of second-order hyperbolic or parabolic equations, maximum principles for parabolic problems, energy method, hyperbolic systems of first-order equations, and the semigroup theory.

13	Complex Variable Function	3	This coure is mainly focused on basic theory of complex variables, including complex domain, analytic functions, elementary functions, integrals, series, residues and poles with their application, mapping by elementary fuctions, conformal mapping with its application, etc.
14	Control Theory	3	This course provides an introduction to Modern control theory for the graduate students in Mathematics science. Control theory is one of the theoretical bases of the areas of operational research and cybernetics, which investigates the general laws of control and communication among machines, living beings (including human beings) and society. Speaking mathematically, it studies the quantitative relationships of information transferring, transforming and processing in controllable systems. It is one of start points to recognize the world for the graduates that mastering the basic theory about systems, information and control, and understanding dynamic motion of system under control. The fundamental topics of the course contain: Mathematical modeling and identification of control systems; Controllability and observability of linear systems; Optimal control theory(Calculus of variations, minimum principle, dynamic programming method); Stability and rubosty; H-infinite optimal control; Filtering theory.
15	Graph Theory	3	The course is devoted to some basic concepts and techniques in modern graph theory. The topics covered include: 1. Flows, Connectivity and Matching; 2. Colouring; 3. Electrical Network; 4. Graphs, Groups and Matrices; 5. Random Graphs; 6. Random Walks on Graphs; 7. The Tutte Polynomial.
16	Advanced Numerical Aanlysis	3	This course is intended to introduce the basic ideas, realization procedure and theoretical analysis about some typical computational methods, with an emphasize on the role of variational principles. The content includes: Variational principles in , preconditioned CG method, Krylov subspace and the Lanczos algorithm; multiplicative and additive parallel domain decomposition methods and the theoretical analysis; classical multigrid methods and the Cascadic grid method with theoretical analysis; Arnoldi's algorithm and the GMRES method for non-symmetric linear systems; ill-posed problems and the Tikhonov regularization method, the regularization method for the first kind of Fredholm integral equations. It is hoped that the students have rather extensive and thorough understanding about some fundamental research areas in scientific computation after the study of the course.

17	Introduction to Mathematical Programming	3	Mathematical programming (MP) covers many important areas in Operational Research and Modern Applied Mathematics, with wide applications in practice. MP studies the optimization problem for scalar or vector-valued objective functions in prescribed regions. The main contents include: 1. We introduce some models, basic concepts and basic solution ideas for MP as well as giving some concepts and results about convex sets and convex functions; 2. we present the basic properties of linear programming(LP), and introduce the Simplex Method and the dual theory; 3. the line search problems are considered including the introduction of optimal and acceptible step methods; 4. we discussthe optimal condition for the nonconstrained nonlinear programming (CNP) and give descent direction methods; 5. we study constrained nonlinear programming(CNP), which includes the theory of optimal conditions and the dual theorem, and the methods of fesible descent directions and penalty functions. The concept of the efficient solution, the optimal condition and common methods of multiobjective programming will be considered in the last part.
18	Stochastic Process	3	This course is measure theoretic introduction to stochastic processes. It covers: General theory of stochastic processes (Kolmogorov existence theorem, processes of independent increments, Markov processes, Gaussian Processes); Martingales (supermartingales and submartingales, the Doob-Meyer decomposition, stopping times, fundamental inequalities, convergence theorems, optional sampling theorem); Discrete-time Markov Chains (weak ergodic theorems, invariant distributions, mean recurrence times, limits of transience probability); Continuous-time Markov Chains (Kolmogorov's backward equation, Markov transition and rate kernels); Brownian motion (sample paths, strong Markov property and the reflection principle, computations based on passage times, stopping time); Markov processes (semigroup, the martingale problem, strong Markov property, Feynman-Kac formulas); Introduction to stochastic analysis (stochastic integration, the Ito formula, the Girsanov theorem, stochastic differential equations, diffusion processes).
19	Data Analysis	3	The contents of this course includes the following topics ： descriptive staistics (collection， understanding and interpretation of data)， statistical inference (probability and probability distribution， sampling and testing)， statistical methods (correlation analysis， regression analysis， time series analysis， clustering analysis， principle component analysis and factor analysis).
20	Commutative Algebra and Homological Algebra	3	This course provides the basics on multi-linear algebra,commutative algebra and homological algebra. The topics includes the following: integral extensions, Hilbert Basis Theorem and Hilbert Nullstellenszasz,, primary decomposition of module, tensor product and exterior algebra, affine algebraic variety and prime ideals of rings, the spectrum of a ring, Krull dimension, regular sequence and depth.

			The following are seminars.
21	Topics on Ordinary Differential Equations(A)	2	This course introduce some advanced concepts related to existence theory, invariant manifolds, continuation of periodic orbits, forced oscillators, separatrix splitting, averaging, and local bifurcation theory. Some basic methods, such as Melnikov's method, the averaging principle and Lyapunov-Schmidt reduction, are also introduced.
22	Topics on Ordinary Differential Equations(B)	2	This course introduce some advanced concepts related to existence theory, invariant manifolds, structural stability, Hamiltonian and gradient system, singular perturbation, and bifurcation theory. Some basic bifurcations such as multiple Hopf bifurcation, Bogdanov-Takens bifurcation,etc are also introduced.
23	Topics on Partial Differential Equations (A)	2	This course concerns the theory of discontinuous solutions to quasilinear hyperbolic conservation laws. It contains some basic theory of Burgers equation, entropy solutions to scalar conservation laws, the Riemann problem for systems of conservation laws in one space variable and applications to gas dynamics, the Glimm Difference scheme, and some basic theory of multidimensional conservation laws.
24	Topics on Partial Differential Equations (B)	2	This course concerns the global existence or blowup of solutions to nonlinear hyperbolic problems. It contains the theory of global existence of large or small solutions, the blowup phenomena of classical solutions in fnite time, estimates on life span, and continuation of solutions. Both of one space variable and several space variables will be studied.
25	Topics on Scientific Computation(A)	2	The course involves the mathematical modeling and numerical methods for elastic problems, introduces numerical methods for some typical inverse problems arising from undamaged detection, and provides an introduction to Wavelet analysis with applications. The content includes: Elastic models in three dimensions, mathematical models for plates and beams by the method of dimension reduction, the principle of minimal potential energy, the mixed variational principle and related numerical methods; numerical computation of heat flux on the interior boundary for the furnace problem, detection of the corrosion coefficient for pipes with erode liquids and EIT methods, and numerical methods for some other inverse problems; introduction to wavelets including discrete wavelet transforms and wavelets with compact support, states properties and other special aspects of wavelets, together with some interesting applications such as image compression and de-noising noisy data. It is hoped that the students have a good understsses). □□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

26	Topics on Scientific Computation(B)	2	The course covers the development of numerical simulation software in Linux system, including Linux operation system, KDE development platform, the use of computational resources in network (LAPACK and visualization software, etc.), MPI parallel computing, the computational methods in different scales(FEM,CA and MD simulations, etc.), and the application of parallel computing and multiscale computational methods in engineering problems (the simulation of alloy solidification and grain growth). The aim of the course is to introduce the latest computational resources and the development of computational packages, using parallel computing and multiscale methods.
27	Topics on Operational Research and Cybernetics (A)	2	This course is designed for the graduate students in mathematics department, which is to provide the materials in the areas of Operational Research and Cybernetics（O& C） that enlarge the insight and deepen the understanding for the students. There exists a great number of distinct kinds of O& C problems. From the viewpoint of mathematics, Operational research relates to static problem, Cybernetics studies the dynamic phenomena. The current topics contain as follow: New progresses of theory and methods in determinative global optimization, Stochastic global algorithms and their theoretical fundamentals, Optimization method for nonlinear equation set, Stochastic optimal control theory, Optimal control theory with distribution systems, Numerical methods to optimal control problems, Intelligent information processing, and Bland signal processing methods.
28	Topics on Operational Research and Cybernetics (B)	2	Operational Research (OR) and Control Theory (CT) are important research areas in the modern applied mathematical. This course is open for the students studying OR and CT. Two parts of following contents will be selected according to students' interesting. Convex analysis part will study convex set, convex function and its subdifferential, Lipschitz function and its G-subdifferential in infinitive dimension. The optimal condition theory ,the dual theory and the algorithm study for multiobjective programming will be investigated in part two. The third part is about semidefinite programming(SDP), which includes the idea of interior point algorithms(IPA), IPA for linear programming, the theory and IPA for SDP, the theory and algorithm study for multiobjective semidefinite programming.

29	Topics on Complex Analysis (A)	2	This course covers some classic fields about complex analysis. It introduces partial fractions of meromorphic functions, product developments of entire functions, Hadamard's theorem, Riemann Zeta functions, Poisson-Jensen's formula; elliptic functions, including simply periodic functions and doubly periodic functions; algebraic functions and algebroid functions, Riemann surface, Nevanlinna theory, including characteristic functions, the first and second fundamental theorems, growth orders, etc; complex differential equations and complex functional equations, etc. The fundamental theory and new developments are both addressed.
30	Topics on Complex Analysis (B)	2	This course covers some frontier fields about complex analysis. It introduces normal families, including equicontinuity, Arzela's theorem, Montel's and Marty's theorems, Zalcman's lemma; univalent functions, including Koebe's and de Branges' theorems; quasiconformal mappings, including conformal length, extremal length, geometric, analytic and metric definitions, quasiconformal extension, distortion theorem, quasicircle; iteration of rational functions, including fixed points, the Fatou and Julia sets, periodic points, Siegel disks, the Hausdorff measure and dimension, etc. Apart from the fundamental and general introduction on complex analysis are introduced, some developments and results in advanced fields are also addressed.
31	Topics on Financial Mathematics	2	This course covers the main topics of the theory, algorithms and applications of mathematical finance. The main cotents include the following：the basic knowledge of Brown motion and stochastic analysis, model of financial market, capital asset pricing, optimal portfolio，risk measure and option pricing both in discrete and continuous time setting. Some numerical methods are also covered.