Program: Mathematics
Degree Offered: Doctorate.

Plan Number		2016	D

STUDY PLAN

I. GENERAL RULES AND CONDITIONS:

1- This plan conforms to the regulations of the general frame of the Doctoral programs.

2- Areas of specialty of admission in this program:
- Holders of the Master degree of Science in:
  (a) Mathematics;
  (b) Mathematical Statistics.

II. SPECIAL CONDITIONS: None.

III. THE PLAN: Studying (54) Credit Hours as follows:

1. Obligatory Courses (21 credit hours):

Course No.	Course Title	Credit hrs.	Pre-request
0301901	Methods of Applied Mathematics	3	–
0301911	Functional Analysis	3	–
0301915	Complex Analysis	3	–
0301921	Matrix Analysis	3	–
0301931	Mathematical Statistics	3	–
0301941	Theory of Groups and Fields	3	–
0301961	Topology	3	–

2. Elective Courses: Studying (18 credit hours) from the following:

Course No.	Course Title	Credit hrs.	Pre-request
0301902	Ordinary Differential Equations	3	0301901
0301903	Partial Differential Equations	3	–
0301905	Dynamical Systems	3	–
0301906	Fractional Calculus	3	–
0301912	Operator Theory	3	0301911
0301914	Geometry of Banach Spaces	3	0301911
0301932	Probability Theory	3	–
0301933	Information Theory	3	–
0301934	Reliability Theory	3	–
0301935	Stochastic Processes	3	–
0301936	Design and Analysis of Experiments	3	–
0301942	Commutative Algebra	3	–
0301943	Algebraic Graph Theory	3	–
0301944	Number Theory	3	0301941
0301945	Rings of Continuous Functions	3	–
0301962	Point Set Topology	3	0301961
0301963	Algebraic Topology	3	–
0301972	Modern Convex Optimization	3	–
0301973	Integer and Combinatorial Optimization	3	–
0301981	Special Topics in Mathematics	3	–

3. Passing the qualifying Exam (0301998).
4. Dissertation: (18) Credit hours (0301999).

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Course Description

0301901 **Methods of Applied Mathematics** **3 Credit Hrs.**

Prerequisite: None.

Boundary value problems for ordinary and partial differential equations, integral transforms, Volterra and Fredholm equations, variational methods, asymptotic methods, distribution theory.

0301902 **Ordinary Differential Equations** **3 Credit Hrs.**

Prerequisite: (0301901)

Existence and uniqueness, Poincare-Bendxion theory, stability theory of linear and almost linear systems, periodic solutions and generalized solutions of ordinary differential equations, nonlinear equations and stability.

0301903 **Partial Differential Equations** **3 Credit Hrs.**

Prerequisite: None.

General theory of first-order equations, the Cauchy problem, second-order equations: characteristics and normal forms, equations of mathematical physics, advanced techniques of solutions.

0301905 **Dynamical Systems** **3 Credit Hrs.**

Prerequisite: None.

Fundamental concepts, extensive survey of examples, equivalence and classification of dynamical systems, principal classes of asymptotic invariants, circle maps, chaos.

0301906 **Fractional Calculus** **3 Credit Hrs**

Prerequisite: None

Special functions of fractional calculus, Riemann-Liouville deferential and integral operators, Caputo's approach, Mittag-Leffler functions, fractional deferential equations (FDE), Numerical solutions of (FDE).

0301911 **Functional Analysis** **3 Credit Hrs.**

Prerequisite: None.

Banach and Hilbert spaces, Hahn-Banach, closed graph, open mapping, and uniform boundedness theorems, duality and weak topologies, convexity, Kerin-Milman theorem, elements of the spectral theory for bounded operators on Hilbert space, compact operators, spectral theorem for compact normal operators, Banach algebras, fixed point theorems.

0301912 **Operator Theory** **3 Credit Hrs.**

Prerequisite: (0301911)

Basic facts about operators on Hiblert space, spectral theorem for normal operators, shift operators, commutators and derivations, subnormal and hyponormal operators, operators in Schatten classes, Algebra of operators.

0301914 Geometry of Banach Spaces **3 Credit Hrs.**

Prerequisite: (0301911).

Reflexive Banach spaces, separable Banach spaces, uniformly convex spaces, strict convexity and smoothness, Gateaux-differentiability of the norm, extreme, exposed and smooth points, best approximation in Banach spaces.

0301915 Complex Analysis **3 Credit Hrs.**

Prerequisite: None.

Open mapping theorem. Positive harmonic functions. The Phragmen-Lindelof method and interpolation. Approximation by rational functions: Runge's theorem, Cauchy's theorem, simply connected regions. Zeros of holomorphic functions: infinite products, the Weierstrass factorization theorem, the Mittag-Leffler theorem, Jensen's formula, Blaschke products, the Muntz-Szasz theorem. Analytic continuation: Regular points and singular points, continuation along curve, The mondormy theorem, construction of a modular function, The Picard theorem. H^p-spaces(Hardy-spaces): Subharmonic functions, the space H^p and N (Nevanlinna class), the theorem of F. and M. Riez, factorization theorems, the shift operator, conjugate functions.

0301921 Matrix Analysis **3 Credit Hrs.**

Prerequisite: None.

Majorization, eigenvalue and singular value inequalities, symmetric norms, spectral radius inequalities, numerical range , numerical radius inequalities, commutator estimates, arithmetic-geometric mean inequalities, Schwarz inequalities, perturbation of matrix functions.

0301931 Mathematical Statistics **3 Credit Hrs.**

Prerequisite: None.

Theory of point estimation: unbiasedness, equivariance, resampling: bootstrap and Jackknife estimates, large sample theory, asymptotic optimality, theory of testing statistical hypotheses, the decision problem, uniformly most powerful tests, unbiasedness, invariance, minimax principles. Bayes methods and sequential analysis.

0301932 Probability Theory **3 Credit Hrs.**

Prerequisite: None.

Infinite divisible laws, matingales, ergodic theory, Markov chains, Brownian motion, renewal theorem, invariance theorem.

0301933 Information Theory **3 Credit Hrs.**

Prerequisite: None.

Functional equations, classification of information measures, survey of well known measures, required properties of information measures, axiomatic approach to characterizations of entropies, extensions of entropies to the continuous case, relationship measures, sufficient partitions and efficiency, maximum-entropy models, Akaiki information criterion and model selection, Kullback-Leibler divergence and testing statistical models.

0301934 Reliability Theory **3 Credit Hrs.**

Prerequisite: : None.

Coherent systems, reliability of coherent systems, classes of distributions of importance in reliability theory IFR, IFRA, NBU, NBUE, DMRL, and their dual classes, shock models, stress-strength models, preservation of life distribution classes under reliability

operations, multivariate exponential distributions, maintenance policies, replace-ment models, some inference problems in reliability theory, limit distributions of coherent system life.

0301935 Stochastic Processes **3 Credit Hrs.**

Prerequisite: None.

Definitions and terminology, classification, Markov chains (discrete and continuous Markov chains), renewal process, martingales, Brownian motion, branching processes, stationary processes, queueing theory, applications.

0301936 Design and Analysis of Experiments **3 Credit Hrs**

Prerequisite: None.

Basic ideas for good experimentation:
(randomization, replication and blocking). Simple comparative experiments. One-way analysis of variance and multiple comparisons. Orthogonal and Polynomial contrasts. Model validation and residual analysis. Regression and analysis of covariance. Factorial experiments and multi-way ANOVA. Factorial designs with fixed, mixed and random effects. Expected Mean squares and Variance components. Additivity and Interactions .Balanced and unbalanced designs. Design efficiency. Nested and crossed designs. Complete and incomplete block designs. Latin square and factor effect confounding. Split-plot and repeated measures designs. Response surface and mixture designs. Factorial designs and design resolution.

0301941 Theory of Groups and Fields **3 Credit Hrs.**

Prerequisite: None.

Further study of group theory: group actions, semidirect product, classification of finite groups, solvable, and nilpotent groups, splitting field of a polynomial, the Galois group, fundamental theorem of Galois theory; the general equation of the nth degree, finite ordered fields, real closed field.

0301942 Commutative Algebra **3 Credit Hrs.**

Prerequisite: None.

Review of modules over commutative rings, chain conditions, projective and flat modules, localizations, domains and ideal theory, integral extensions, valuation rings.

0301943 Algebraic Graph Theory **3 Credit Hrs.**

Prerequisite: None.

Review of basics in graph theory, matrices and graph theory, characteristic polynomial, chromatic polynomials, automorphism groups, symmetry and regularity of groups, graph enumerations, Polya theorem.

0301944 Number Theory **3 Credit Hrs.**

Prerequisite: (0301941)

Algebraic numbers, algebraic integers, trace, norm, discriminant, integral basis, prime factorization of ideals, Dirchlet unit theorem, ideal class group, Minkowski's bound.

0301945 Rings of Continuous Functions **3 Credit Hrs.**

Prerequisite: None.

Ideals and z-filters, completely regular spaces, fixed ideals, compact spaces, ordered residue class rings, the Stone Cech compactification, characterization of maximal ideals.

0301961 Topology **3 Credit Hrs**

Prerequisite: None.

Quotient spaces and quotient mappings, function spaces, compactifications, Stone-Cech compactification, perfect mappings, Lindelof spaces, countably compact spaces, pesudocompact spaces and sequentially compact spaces, real compact spaces, paracompact spaces, countably paracompact spaces, weakly and strongly paracompact spaces.

0301962 Point Set Topology **3 Credit Hrs.**

Prerequisite: (0301961)

[a,b]-compact spaces, spaces related to normal spaces, expandable spaces, generalizations of paracompact spaces and related spaces, product theorems, metrization theorems.

0301963 Algebraic Topology **3 Credit Hrs.**

Prerequisite: None.

The homotopy relations, the fundamental group, covering spaces, foundamental group of a covering space foundamental group an orbit space, lefting theorems Seifert-Van Kampen theorem, homology theory.

0301972 Modern Convex Optimization **3 Credit Hrs.**

Prerequisite: None.

Theory and algorithms for constrained convex optimization including optimality conditions, duality theory, applications, interior-point methods, penalty and barrier methods.

0301973 Integer and Combinatorial Optimization **3 Credit Hrs.**

Prerequisite: None.

Theory and applications of integer and combinatorial optimization including enumerative, cutting plane, basis reduction, relaxation and matching methods.

0301981 Special Topics in Mathematics **3 Credit Hrs.**

Prerequisite: None.

Topics to be chosen from various fields of mathematics.