Ph.D in MATHEMATICS

INTRODUCTION
The Department of Mathematics (College of Science) offers a Ph.D. program in **Mathematics**. Only full-time students are admitted to this program. Current research interests of the faculty include: Differential Equations, Numerical analysis, Integral Transforms, Fractional Calculus, Algebra (Ring Theory); analysis (Functional Analysis, Operator Theory); Approximation Theory and Fourier Analysis, Geometry, (General Topology), Differenial Geometry, Algebraic Topology Combinatorics, and Dynamical Systems.

PROGRAM REQUIREMENTS
18 TOTAL COURSE CREDITS

6 COMPULSORY COURSES (3 credits each)
    0410-501 Algebra I
    0410-510 Analysis I
    0410-512 Complex   Analysis I
    0410-513 Ordinary Differential Equations
    0410-515 Functional   Analysis
    0410-525 General Topology

9 ELECTIVES* (3 credits each)
    *The student must take at least 9 credit hours of the 600-level courses listed below
    (each is 3 credits) that are offered by the department of Mathematics, with the consent
    of the Program Committee.

    0410-601   Algebra
    0410-603   Ring Theory
    0410-606   Group Theory
    0410-608   Advanced Topics in Algebra
    0410-610   Measure and Integration Theory
    0410-612   Complex   Analysis
    0410-614   Operator Theory
    0410-615   Functional   Analysis
    0410-616   q-Analysis
    0410-617   Methods of Mathematical Physics
    0410-618   Advanced Topics in Analysis

0410-623   Advanced Topics in Applied Mathematics
0410-625   Topology
0410-626   Algebraic Topology
0410-635   Advanced Topics in Geometry and Topology
0410-636   Graph Theory
0410-637   Theory of Linear Programming
0410-638   Advanced Topics in Discrete Mathematics
0410-650   Approximation and Optimization
0410-661   Numerical Solution of Partial Differential Equations
0410-668   Advanced Topics in Numerical Mathematics
0410-690   Seminar in Mathematics

3-6 A student may include in the program of study up to 6 credit hours from 500 or 600-level courses offered by other graduate programs within Kuwait University.

NC COMPULSORY (0)
0410-697   Dissertation
0410-698   Dissertation
0410-699   Dissertation

COURSE DISCRIPTION

0410-601:   ALGEBRA
           CR: 3
Monoids, groups and subgroups; normal and quotient groups. Direct products, direct sums and free groups. Free products, generators and relation. Rings, factorization of commutative rings, rings of quotients and localization. Rings of polynomials and formal power series. Factorization in polynomial rings. Modules and exact sequences, injective and projective modules. Matrices, rank and equivalence.

0410-603:   RING THEORY
           CR: 3
Primitive rings, simple rings with minimal ideals, Jacobson radical, semi-simple rings , and Artinian semi-simple rings,. Completely reducible modules. Tensor product (elementary properties). Inductive and projective modules and semi perfect rings.

0410-606:   GROUP THEORY
           CR: 3
Automorphisms of group. The holomorph, complete groups and semi-direct product of groups. Free groups and Schreier method. Solvable groups and extended Sylow theorems and Frattini subgroups. Abelian groups: torsion, torsion free, divisible and pure subgroups.

0410-608:   ADVANCED TOPICS IN ALGEBRA
           CR: 3
Selected Advanced Topics in Algebra that will reflect recent advances.

0410-610:   MEASURE AND INTEGRATION
           THEORY
           CR: 3
Abstract measure and integration, the Lebesgue integral, Dini derivatives and the fundamental theorem of Calculus.

0410-612:   COMPLEX ANALYSIS
          CR: 3

Analytic continuation, Harmonic functions, Mapping theorems. The modular function, Entire functions.

0410-614:   OPERATOR THEORY
          CR: 3

Hilbert spaces and Banach spaces. Duality, linear operators, compact operators, and Fredholm operators.

0410-615:   FUNCTIONAL ANALYSIS
          CR: 3

Function spaces, linear functionals and distributions. Convolutions and Fourier transforms. sobolev spaces, embedding theorems.

0410-616:   Q-ANALYSIS
          CR: 3

q-binomial theorem. Basic hypergeometric series and summation formula. q-analogues of the classical orthogonal polynomials. Applications in analysis, number theory, combinatorics, Physics and computer Algebra.

0410-617:   METHODS OF MATHEMATICAL
          PHYSICS
           CR: 3

Linear transformations and quadratic forms. Orthogonal systems. Fourier series and the Fourier integral. Linear integral equations. Calculus of variations. Eigenvalue problems. Special functions defined by eigenvalue problems and fractional calculus. Heat and wave equations.

0410-618:   ADVANCED TOPICS IN ANALYSIS
          CR: 3

Advanced Topics in Analysis will include recent advances.

0410-623:   ADVANCED TOPICS IN
          APPLIED MATHEMATICS
          CR: 3

Advanced Topics in Applied Mathematics will include recent advances.

0410-625:   TOPOLOGY
          CR: 3

Advanced Topics in function spaces, uniform spaces, compacitifications and applications. Surfaces, fundamental groups and covering spaces.

0410-626:   ALGEBRAIC TOPOLOGY
          CR: 3

Simplicial homology, homotopy theory, homotopy groups. Cohomotopy, singular homotopy.

0410-635:   ADVANCED TOPICS IN   GEOMETRY
          AND TOPOLOGY
          CR: 3

Advanced Topics in Geometry and Topology will include recent advances.

0410-636:   GRAPH THEORY
          CR: 3

Matchings in bipartite graphs, perfect matchings, Konig's theorem. Matchings in a general graph. Tutte's theorem, f-factor theorem. Colorings of graphs, vertex coloring, Brook's theorem, edge colorings, Vising's theorem . Ramsey theory and other external problems.

0410-637:   THEORY OF LINEAR
          PROGRAMMING
          CR: 3

Theory of linear optimization and modeling techniques. Convex analysis, duality theory and KKT optimality conditions. Sensitivity analysis, primal, dual and primal-dual simplex algorithm. Convergence and implementation issues.

0410-638:   ADVANCED TOPICS IN
          DISCRETE MATHEMATICS
          CR: 3

Advanced Topics in Discrete Mathematics, in particular in combinatorics, graph theory and/or linear programming, will include recent advances.

0410-650:   APPROXIMATION AND
          OPTIMIZATION
          CR: 3

Formulation of Approximation and Optimization problem in function spaces. Normal spaces, and dual spaces. Convex sets, separation theorem and differentiability properties of convex function. Optimality criteria (Karush-Kuhn-Tucker variational inequalities). Least square problems in Hilbert spaces, finite dimensional approximation, and Chebychev approximation. Duality and saddle points.

0410-661: **NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**
CR: 3

Characteristics and boundary conditions for first and second order PDEs. Finite different methods. Semi-discretization (MOL). Finite elements, Petrov-Galerkin methods. Discretization of eigenvalue problems.

0410-668: **ADVANCED TOPICS IN NUMERICAL MATHEMATICS**
CR: 3

Advanced Topics in Numerical Mathematics will include recent advances.

0410-690: **SEMINAR IN MATHEMATICS**
CR: 3

The aim of the seminar in Mathematics is to have the student learn about the state of the art of current research in a specific area of Mathematics and gain experience in presenting and discussing material assigned by the seminar instructor.

0410-697: **DISSERTATION**
CR: 0

0410-698: **DISSERTATION**
CR: 0

0410-699: **DISSERTATION**
CR: 0