**DEPARTMENT OF MATHEMATICS**

**POSTGRADUATE PROGRAMMES IN PURE AND APPLIED MATHEMATICS**

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**PHILOSOPHY**

**It is becoming very obvious that Mathematics is the arrowhead of development not only in the Sciences - engineering sciences, physical sciences, social sciences, medical sciences – but indeed in all facets of the economy of any nation. Thus the postgraduate programme in mathematics is designed to provide training in the theory and application of mathematics in every area of human endeavour and stimulate creative thinking and research in every area of mathematics. The programme emphasizes an in-depth study of mathematical methods and solution of real life problems**

**LISTS OF APPROVED SUPERVISORS**

1. **PROFESSORS**

Amazigo, J. C. (FAS) B.Sc. (RPI), M.Sc., Ph. D (Harvard) Applied Mathematics

Chidume, C. E. (FAS) B.Sc. (Nigeria), M.Sc. (Queens), Ph.D Nonlinear Operator Theory

(Ohio state)

Eke, A. N. B.Sc., M.Sc., Ph. D (Nigeria) Control Theory

Osilike, M. O. B.Sc., M.Sc., Ph. D (Nigeria), DICTP (Trieste) Nonlinear Operator Theory

Oyesanya, M. O. B.Sc., M.Sc., Ph. D (Nigeria) Applied Mathematics

Ochor, F. I. B.Sc., M.Sc. (Nigeria), M. Phil, Ph. D (SISSA) Differential Equations

Mbah, G. C. E. B.Sc., M.Sc. (Benin), Ph. D (Nigeria) Modeling

**SENIOR LECTURERS**

Obi, E. C. B.Sc. (I. C. Portland), M.Sc., Ph. D (Toledo) Summability Theory

LECTURER I

Shehu, Y. B. Sc (Ladoke Akintola), M. Sc.(Nigeria) Ph. D (AUST) Functional Analysis

**DEPARTMENT OF MATHEMATICS**

**POSTGRADUATE DIPLOMA (PGD) IN MATHEMATICS**

**POST GRADUATE DIPLOMA (PGD) IN MATHEMATICS**

**The PGD program in Mathematics is designed to cater for graduates of other Departments in Physical Sciences, Engineering, Mathematics Education and mathematically related disciplines who may want to pursue higher degrees in Mathematics. The PGD program is NOT meant for graduates of Mathematics with Third Class.**

**OBJECTIVES:**

**The main objective of the PGD programme is to open the door of the universal language of mathematics to non-mathematics graduates to enter into productive field of Science and technology, communication and information technology, financial mathematics, and give to those interested and qualified a solid background in mathematics for higher degrees and scientific breakthroughs.**

**ADMISSION REQUIREMENTS**

Candidates for the PGDmust possess a first degree in related disciplines as noted above with a CGPA of not less than 2.5/5.0 in addition to General Certificate of Education (GCE) O/L with five credits including English Language, Mathematics, Physics and any other two physical science subjects.

**FIRST SEMESTER.**

1. MTH 511 ANALYTICAL DYNAMICS 3
2. MTH 521 NUMERICAL ANALYSIS 3
3. MTH 531 FINANCIAL MATHEMATICS 3
4. MTH 541 REAL ANALYSIS 3
5. MTH 551 ABSTRACT ALGEBRA 3
6. MTH 561 PARTIAL DIFFERENTIAL EQUATIONS 3
7. MTH 571 MATHEMATICAL METHODS 3
8. MTH 581 MEASURE AND INTEGRATION 3

**SECOND SEMESTER**

1. MTH 512 COMPLEX ANALYSIS 3
2. MTH 522 ORDINARY DIFFERENTIAL EQUATIONS 3
3. MTH 532 TOPOLOGY 3
4. MTH 542 FUNCTIONAL ANALYSIS 3
5. MTH552 ADVANCED CALCULUS 3
6. MTH 562 MATHEMATICAL MODELING 3
7. MTH 572 OPERATION RESEARCH 3
8. MTH 582 CONTROL THEORY 3
9. MTH 592 BANACH ALGEBRA AND SPECTRAL THEORY3

Minimum of 15units to be taken

Total = 30units

Project = 4units to be taken DURING first semester to the students and examined at the end of the second semester.

**COURSE CONTENTS**

**MTH 592 BANACH ALGEBRAS AND SPECTRAL THEORY**

A brief review of Banach Space Theory. Basic of Banach Algebras. The Functional Calculus. The Spectrum. Commutative Banach Algebras. Bounded Operators on a Hilbest Space, Unbounded Operators. The Spectral Theory of Operators CA- Algebras and Von Neumann Algebras.

**MTH 542 FUNCTIONAL ANALYSIS**

Normed Linear spaces. An introduction to Operators Hilbest Spaces. Topological Vector Spaces. The Hahn-Banach Theorem. Weak Topologies and Dual Spaces. Local Compactness and External points. Operator Theory.

**MTH 551 ABSTRACT ALGEBRA**

Basic Axioms and Examples of Groups Subgroups and Lattice of Subgroups. Quotient Groups and Homomorphosms. P-groups Nilpotent Groups and Solvable Groups. Definition of a Ring. Ring Homomorphism and Quotient Rings. Euclidean Domains, Principal Ideal Domains and Unique Factorization Domains. Polynomial Rings. Review of Field Theory and Galois Theory.

**MTH 532 GENERAL TOPOLOGY**

Brief Review of Set Theory and Logic. Topological Spaces and Continuous Functions. Connectedness and Compactness. Countability and Separation Axioms. The Tychonoff Theorem. Metrization Theorem and Paracompactness. Complete Metric Spaces and Function Spaces. Baire Spaces and Dimension Theory.

**MTH 552 ADVANCED CALCULUS**

Functions of Several Variables. Functions from Rn  to Rn. partial Derivatives. Jacobian. Inverse Function Theorem. Implicit Function Theorem.

**MTH561 PARTIAL DIFFERENTIAL EQUATIONS**

Basic examples of linear partial differential equations, their fundamental equations and solutions. The Cauchy problem for the linear second order partial differential equations in two independent variables; existence and uniqueness of solutions; normal forms. Riemann method. Hyperbolic, elliptic and parabolic partial differential equations. Boundary value and mixed boundary value problems.

**MTH541 REAL ANALYSIS**

Review of: The Concept of upper and lower limits of bounded sequences. Category Spaces, the Bairew Category Lemma, the Unit Open Ball Lemma, Zorn’s Lemma, Basic Properties of Hilbert Space and Banach Spaces. Theory of Functions of a Real Variable. Lebesgue Measure and Integral. Differentiation and Integration.

**MTH 581 MEASURE AND INTEGRATION**

Basic Definitions and Examples. Measures and Outer Measures. Extensions of Measures. Measurable Functions. Integration. General Set Functions.

**MTH 511 ANALYTICAL DYNAMICS (3)**

Motion of rigid bodies. Generalized coordinates conservative fields. Degrees of freedom. Holonomic and non-holonomic systems. Languages equation for holonomics systems, force dependent coordinates only, force obtainable from a potential. Hamilton’s equation, Impulsive motion, Small oscillative. Normal modes, Three-dimensional motion. Eulerian angles, spinning tops, gyrostats, rolling bodies and frames of reference. Calculus of variation.

**MTH 521 NUMERICAL ANALYSIS**

Numerical differentiatives and integration by various methods. Guassina quadratine. Numerical method for ordinary and partial differential equations. Boundary value problems. Computation of eigenvalues of symmetric matrices. Finite Difference methods, equations and operatives. Discrete variable methods for solutions of IVPS ordinary differential equations. Discrete and continuous Tan methods for solving IVP-ODES, error analysis.

**MTH 531-FINANCIAL MATHEMATICS (3)**

Measures of central tendency, retives and correlative. Distribution theories and types of distributives. Stocks and shares. Risks analysis of stock and shares. Investments and returns on investment. Portfolio selection. Optimizing returns on portfolios selection.

**MTH 571- MATHEMATICAL METHODS**

Gradient, divergence and curl of vectors. The integral definition of gradient, divergence and curl of vectors curvilinear coordinates. Simple notion of tensors. Calculus of variation; Lagrange’s functional and associated density. Conditions for strong and relative extremum. Geodesic problems. Variable end point theorems and related theorems. Isoperimetric problems. Variational integral transforms: Laplace, Fourier, Hankel and Mellen transforms. Complex variable methods, convolution theorem and applications to solutions of IVP/BVP ODES. Series solutions of second order equation about ordinary and regular singular points: application.

**MTH 562 MATHEMATICAL MODELLING**

Methodology of model building. System study and abstractions of relevant information for mathematical formulation of the required equations. Various types of mathematical model formulation: Descrete, Stochastic, Differential, Integra – differential, algebraic difference etc. application of the art of mathematical modeling to; environmental studies, economy, physical, biological, drug Kinetics, Chemical reactions. Simulations and interpretation of model results.

**MTH 572: OPERATION RESEARCH (3)**

Inventory problem; graph and networks; stock control; quelling problems. Decision theory. Non- linear programming algorithms and their reliability. Scheduling. Special types of linear programming problems. The dual simplex methods. Advanced topics in Mathematical programming. Dynamics programming. Game theory. Integer and mixed programming.

**MTH 582 CONTROL THEORY**

Existence, boundedness and periodicity for solutions of linear systems of differential equations with content coefficients. Stability theorems and analysis for differential equations: Lyapuno and other methods. Sets: reachable sets, attainable sets. Dynamical systems in the space. Reachability, stabilizability and detectability. Equivalence of controllability and pole assignability.

**MTH 512 COMPLEX ANALYSIS**

Analytic functions and conformal mappings. Analytic contimatives and elementary Riemann surfaces. Transformations, infinite products; entire functions: include order and types. The product theorems of Weierstrass and others; the Riemann mapping theorems.

**MAT 506 Group Representation Theory 3 Credit Units**

Representation of groups by linear transformations; group algebras, character theory and modular representations. Representation theory of algebraic groups, representation of finite groups; representation of compact and locally compact groups; representation of Lie groups. Unitary representation theory

**DEPARTMENT OF MATHEMATICS**

**MASTERS (M. Sc) DEGREE PROGRAMME**

**MASTER’S (M. Sc) DEGREE PROGRAMME**

**The department offers Academic Master’s Degree and Doctor of Philosophy (Ph. D) Programmes in Pure and Applied Mathematics with specialization in the following areas: Topology, Real Analysis, Functional Analysis, Differential Equations, Continuum Mechanics, Solid Mechanics, Fluid Mechanics, Modeling, Optimization, Control Theory, Operator Theory and Summability Theory.**

**ADMISSION REQUIREMENT FOR MASTER’S PROGRAMME**

1. **Candidates with Bachelor’s degrees from approved university must obtain a minimum second class lower division with a CGPA of 2.5/5.0**
2. **All candidates must have five credit passes including English Language, Mathematics and two relevant science subjects at O’Level preferably Physics and Chemistry or Biology or Geography.**

**MODE OF STUDY:**

**The Academic Master’s degree shall be for four semesters by coursework and project report or by coursework and research dissertation for full time students and six semesters for part-time students . Every Master’s degree student shall take 24 credit units from the core courses INCLUDING general courses, project/dissertation and seminar AND 6 credit units from the elective courses relevant to area of specialization.**

**CORE COURSES**

* **MTH 800/MTH 561 Research Project/Dissertation 6 Credit Units**
* **MTH 802 Topology 3 Credit Units**
* **MTH 803 Real Analysis 3 Credit Units**
* **MTH 804 Complex Analysis 3 Credit Units**
* **MTH 805 Partial Differential Equations 3 Credit Units**
* **MTH 807 Advanced Methods of Applied Maths. 3 Credit Units**
* **MTH 806 Asymptotics Method 3 Credit Units**
* **MTH 808 Geometry of Banach Space 3 Credit Units**
* **MTH 824 Seminar 2 Credit Units**

**REQUIRED GENERAL CORE COURSES**

* **PGC 601 ICT and Research Methodology 3 Credit Units**

**ELECTIVE COURSE**

**The M. Sc. Student in addition to the above specified core course must take 6 Credit Units from the following elective courses:**

1. **PURE MATHEMATICS OPTION**

**MAT 801 Algebra 3 Credit Units**

**MAT 809 Group Representation theory 3 Credit Units**

**MAT 810 Number Theory 3 Credit Units**

**MAT 811 Category Theory 3 Credit Units**

**MAT 812 Lie Groups 3 Credit Units**

**MAT 813 Differential Manifold 3 Credit Units**

**MAT 814 Theory of Integration 3 Credit Units**

**MAT 815 Integral Equations 3 Credit Units**

**MAT 816 Theory of Distributions 3 Credit Units**

**MAT 817 Introduction to Mathematical Modelling 3 Credit Units**

1. **APPLIED MATHEMATICS OPTION**

**MAT 818 Quantum Mechanics 3 Credit Units**

**MAT 819 Fluid Mechanics 3 Credit Units**

**MAT 820 Elasticity 3 Credit Units**

**MAT 821 Electromagnetic Theory 3 Credit Units**

**MAT822 Visco-Elasticity and Plasticity 3 Credit Units**

**MAT 823 Control Theory 3 Credit Units**

**MAT 824 Finite Element Methods 3 Credit Units**

**MAT 825 Biomathematics 3 Credit Units**

**MAT 827 Fractional Calculus and Applications 3 Credit Units**

**DEPARTMENT OF MATHEMATICS**

**DOCTORAL (Ph. D) DEGREE PROGRAMME**

**DOCTORAL (Ph. D) PROGRAMME**

**ADMISSION REQUIREMENT FOR DOCTORAL PROGRAMME**

1. **Candidates with Bachelor’s degrees from approved university must obtain a minimum second class lower division with a CGPA of 2.5/5.0**
2. **All candidates must have five credit passes including English, Mathematics and two relevant science subjects at O’Level preferably Physics and Chemistry or Biology or Geography.**
3. **Candidates must have Academic Master’s degree in Mathematics in relevant area with a CGPA of 4.0/5.0 and thesis score not lower than 60%**
4. **Candidates must demonstrate adequate intellectual capacity, maturity and effective decision making and problem solving potentials.**

**OBJECTIVES:**

**Our postgraduate programmes have the following objectives:**

1. **Production of high caliber mathematicians equipped to man leadership positions in academia, industries, research centres where a sound knowledge of mathematics and mathematical thinking and skills are required particularly in a burgeoning economy like ours.**
2. **Training a crop of mathematicians that can give incisive breakthroughs in understanding, and modeling of epidemiological diseases, engineering structures, and concise development and progression in modern day diseases like cancer, diabetes, high blood pressure etc.**
3. **Training people that can stand with their heads high up engaging in cutting edge research in mathematics.**

**MODE OF STUDY:**

**The doctoral Ph. D degree shall be for six semesters (minimum) and ten semesters (maximum) by coursework and research thesis. Every doctoral student shall take 30 credit units INCLUDING thesis of 12 Credit Units, seminar 6 credit units and 12 credit units of taught courses consisting of 6 credit units from departmental courses and 6 credit units from PG School organized courses namely**

**PGC701 Synopsis and Grant writing 3 Credit Unit**

**ELECTIVE COURSES**

**The Ph. D Student in addition to the above specified core course must take 6 Credit Units from the following elective courses:**

1. **PURE MATHEMATICS OPTION**

**MAT 801 Algebra 3 Credit Units**

**MAT 809 Group Representation theory 3 Credit Units**

**MAT 810 Number Theory 3 Credit Units**

**MAT 811 Category Theory 3 Credit Units**

**MAT 812 Lie Groups 3 Credit Units**

**MAT 813 Differential Manifold 3 Credit Units**

**MAT 814 Theory of Integration 3 Credit Units**

**MAT 815 Integral Equations 3 Credit Units**

**MAT 816 Theory of Distributions 3 Credit Units**

**MAT 817 Introduction to Mathematical Modelling 3 Credit Units**

1. **APPLIED MATHEMATICS OPTION**

**MAT 818 Quantum Mechanics 3 Credit Units**

**MAT 819 Fluid Mechanics 3 Credit Units**

**MAT 820 Elasticity 3 Credit Units**

**MAT 821 Electromagnetic Theory 3 Credit Units**

**MAT822 Visco-Elasticity and Plasticity 3 Credit Units**

**MAT 823 Control Theory 3 Credit Units**

**MAT 824 Finite Element Methods 3 Credit Units**

**MAT 825 Biomathematics 3 Credit Units**

**MAT 827 Fractional Calculus and Applications 3 Credit Units**

**DESCRIPTION OF COURSES**

**PGC 701 Synopses and Grant Writing 3 Credit Units**

**Identification of types** and nature of grants and grant writing: mining of grants application calls on the internet. Determining appropriate strategy for each grant application. Study of various grant application structures and contents and writing of concept notes, detailed project description, budgeting and budget defence. Study of simple grant writings in various forms and writing of mock research and other grants. Identification of University of Nigeria synopsis structure and requirements (Introduction, Methodology and Results). Determining the content of each sub-unit of the synopsis. Steps in writing the synopsis from the Dissertation/Thesis document. Structural and Language issues. Common errors in synopsis writing and strategies for avoiding them. The roles of the students and supervisors in the productionof a synopsis. Writing of mock synopsis. All registered Ph. D students must attend a solution-based interactive workshop to be organized by the School of Postgraduate Studies for a practical demonstration and application of the knowledge acquired from the course conducted by selected experts.

**MAT 801 Algebra 3 Credit Units**

Sylow theorems, direct products, fundamental theorem of finite Abelian groups, fields of quotient, Eucledean rings, polynomial rings over commutative rings, inner product spaces, theory modules, sub-modules, quotient modules, modules over principal ideal domains. Application of finitely generated Abelian group field extension fields elements of Galois theory, solvability radicals.

**MAT 802 Topology 3 Credit Units**

Review of categories and functors. Homology, fundamental group, covering transformation, simplicial complexes. Singular homology. Universal co-efficient theorem for homology and cohomology. Spectral sequence.

**MAT 803 Real Analysis 3 Credit Units**

Measures and integration. Outer measure, Lebesgue Measure. Basic propertics of Banach and Hilbert Spaces. Operators, Duality. Basic theorems in functional analysis. Classical Banach Spaces. Spectral theory of operators in Hilbert spaces. L2 space as a Hilbert space. Banach Algebras. Gelfand theory, compact operators. Examples and applications to classical analysis.

**MAT 804 Complex Analysis 3 Credit Units**

Periodic functions, Weierstrass functions, elliptic curves. Modular forms. Algebraic functions, Riemann surfaces. Covering surfaces, covering transformations. Discontinuous groups of linear transforms, automorphic forms.

**MAT 805 Partial Differential Equations 1 3 Credit Units**

Basic examples of linear partial differential equations and their fundamental equations and their fundamental solutions. Existence and regularity of solutions (Local or Global) of the Cauchy problems; boundary value problems and mixed boundary value problems. The fundamental solutions of their partial differential equations.

**MTH 807 Advanced Methods of Applied Maths. 3 Credit Units**

**The** emphasis will be on advanced methods of solution rather tan theory of ordinary and partial

Differential equations. Power and product series and special functions, contour integral representation, integral transforms, conformal mapping. Wiener-Hopf techniques.

**MTH 806 Asymptotics Method 3 Credit Units**

Asymptotic sequences and series, operations on asymptotic series, asymptotic evaluation of functions defined by contour integral including method of stationary phase and steepest descent,

uniform asymptotic expansion, asymptotic solutions of ordinary and partial differential equations, WKB approximations, singular perturbation.

**MAT 808 Geometry of Banach Space 3 Credit Units**

Uniformly convex spaces and their characteristic inequalities. Strictly Convex Spaces, The Modulus of Convexity. Uniform Uniformly Smooth Banach Spaces and their Characteristic Inequalities, the Modulus of Smoothness, Fretchet and Gateaux Differentiabilities. Duality Maps. Some Applications.

**MAT 809 Group Representation Theory 3 Credit Units**

Representations of groups by linear transformations; group algebras, character theory and modular representations. Representation theory of algebraic groups; representation of finite groups; representation of compact and locally compact groups; representation of Lie groups. Unitary representation theory.

**MAT 810 Number Theory 3 Credit Units**

Algebraic integers. Completions, the different and discriminant. Cyclotomic fields. Parallelotopes. Class-Number. Ideles and Adeles. Elementary properties of Zeta-functions. L-functions.

**MAT 811 Category Theory 3 Credit Units**

Categories, functions natural-transformation. Functor categories, limits. Products and corproducts. Pushbacks and Pushouts, adjoing functors. Normal and exact categories: Abelian categories, quotient categories.

**MAT 812 Lie Groups 3 Credit Units**

Lie groups and their Lie algebras, subgroups. Matrix groups: One-parameter groups, exponential map, Campbell-Hausdorff formula, Lie algebra of a matrix group, integration on matrix groups. Abstract Lie groups.

**MAT 813 Differentiable Manifolds 3 Credit Units**

General manifolds. Topics such as smooth mappings, Immersions, submersions, transversality, intersection theory, vector fields of manifold; orientation of manifolds: Gaussian curvature, Riemannian manifolds, differential forms, integration on manifolds tensors and connections are included.

**MAT 814 Theory Of Integration 3 Credit Units**

The theory on closed and bounded intervals: Gauges and integrals. Basic properties of the integral. The fundamental theorems of calculus. The Saks-Henstock Lemma. Measurable functions. Absolute integrability. Convergence theorems. Integrability and mean convergence. Measure, measurability and multipliers. Mode of convergences, substitution theorems. Applications. The theory on infinite intervals: General insight into integration on infinite intervals.

**MAT 815 Integral Equations 3 Credit Units**

Basic existence theorems: Equations with L2 kernels: Fredholm Theory; Nonlinear equations, Schauder fixed point theorem. Dual integral and series equations. Wiener-Hope equations and Technique. Singular Integral equations. Applications.

**MAT 816 Theory Of Distributions 3 Credit Units**

Topological vector spaces and generalized functions; Distribution calculus and topology; convolution; Tempered distributions and their Fourtier transforms. Integral transforms of Mathematical Physics. Application.

**MAT 817 Introduction To Mathematical Modeling 3 Credit Units**

Mathematical modeling. The Art of Transforming Real Life Situation into Mathematical statements. Examples will be drawn from Areas such as Biology, Business, Deformable Media, Industry and other dynamical system. Case studies.

**MAT 818 Quantum Mechanics 1 3 Credit Units**

Background of the axiomatic approach to Nul et al. axioms of continuum and Basic Concepts. Constitutive relations. Equations of Motion and other Equations. Equations of Motions and other Equations of Balance. The place of the Classical Theories.

**MAT 819 Fluid Mechanics 3 Credit Units**

Thermodynamics Compressive flow; waves; shocks; supersonic flow; Boundary Layer Theory; stability Turbulence.

**MAT 820 Elasticity 3 Credit Units**

Formulation of the Linear Theory; General Theorems; Plane Strain and generalized Plane stress; Ary’s solution: Papkovich – Neuber representation; Basic singular solutions; Boundary – value and Boundary – initial value problem.

**MAT 821 Electromagnetic Theory 3 Credit Units**

Maswell’s Equations; Electromagnetic Potentials: Tensor Calculus; Stress and Energy; Electro Static and Magnetostatics, plane Waves, cylindrical and Spherical waves; Boundary Value Problems; Relativistic Kinematics and Lorentz Transformation: Electrodynamics.

**MAT 822 Quantum Mechanics II 3 Credit Units**

Schrodinger equations; Stone’s Theorem and its applications. Unitary transformations: Heisenberg representation: Measurement: Quantum Theory of Scattering; Angular Momentum. Motion in an external field; Base and Fermi Statistics: Perturbation Theory.

**MAT 823 Visco – Elasticity And Plasticity 3 Credit Units**

Characteristics of various visco-elastic and Plastic material, Basic equations. Boundary Value Problems. Elastic-plastic problem.

**MAT 824 Control Theory 3 Credit Units**

Dynamical Systems in the State Space. Reachability. Stabilizability and Detectability. Equivalence of Controllability and Pole Assignability. The Calculus of Variations. Generalized Huygen’s Principle. The Algebraic Riccati Equation. Lyapunov Stability. Applications to Economic Stabilization. Planning. Manpower Development. Resource Allocation under Constraints, etc Case Studies.

**MAT 825 Finite Element Methods 3 Credit Units**

Introduction to the Finite Element Method: Formulation of the Finite Element Method using the Principle and Virtual Displacement. General Isoparametric Formulation, and Variational Techniques. Generalization of the theory. Application of the Finite Element Method to the solution of Engineering Problems e.g., in Solid Mechanics. Heat Transfer. Fluid Dynamics and Mass Transfer. Development of appropriate Computer Programme. Case Studies.

**MAT 826 Biomathematics 3 Credit Units**

Mathematical Methods of Deterministic or Stochastic aspects of Biological Systems e.g., Population dynamics, species interaction malaria epidemic, etc.

**MAT 827 Fractional Calculus and Applications 3 Credit Units**

Preliminaries – function spaces, continuity, special functions of the fractional calculus – gamma functions, Mittag-Leffler functions.; fractional integrals and fractional derivatives; fractional differential equations ; methods of solving FDEs – Laplace transforms method, fractional Green’s function ; Applications to models in engineering, Physics, Fluid flows, Cancer and epidemiology.