Up to 2018/2019 batch

Department of Mathematics, Faculty of Science, University of Colombo

Syllabi of undergraduate courses conducted by department

Level I:

PM 1001	AM 1001	FM 1001	MS 1002
PM 1002	AM 1002	FM 1002	MS 1004
PM 1004	AM 1003	FM 1004	
	AM 1005	FM 1005	
	AM 1006		
	AM 1008		

Level II:

PM 2001	AM 2001	FM 2001	MS 2002
PM 2002	AM 2002	FM 2002	MS 2003
PM 2004	AM 2003	FM 2004	
	AM 2004	FM 2005	
	AM 2005		

Level III:

PM 3001	AM 3002	FM 3001	MS 3001
PM 3002	AM 3004	FM 3002	MS 3005
PM 3003	AM 3005	FM 3003	MS 3008
PM 3050	AM 3006	FM 3004	
PM 3052	AM 3007	FM 3006	
PM 3053	AM 3008	FM 3007	
PM 3054	AM 3009		
PM 3055	AM 3050		
PM 3056	AM3051		

Level IV

PM 4001	AM 4001	FM 4001	
PM 4002	AM 4002	FM 4002	
PM 4003	AM 4003	FM 4003	IT 4001
PM 4004	AM 4004	FM 4004	IT 4002
PM 4005	AM 4005	FM 4005	
PM 4006	AM 4006	FM 4006	
PM 4007	AM 4007	FM 4007	
PM 4050	AM 4008		
PM 4051	AM 4011		
	AM 4012		
	AM 4013		

PM 1001 Calculus I (30L, 2C)

Rationale: *This course unit is introduced to offer a theoretical understanding of essential topics in calculus.*

Prerequisites: None.

Expected learning outcomes:

By the end of the course, students should be able to

- *Describe rationals and irrationals as dense dents in the set of real numbers*
- *Solve elementary examples involving modulus*
- *Define real functions, function types and inverse functions*
- *Compute limits and derivatives of functions*
- *Apply intermediate value theorem, Max Min value theorem and mean value theorem*
- *Describe continuity and differentiability of a function*

Course Content:

Inequalities: Algebra of basic inequalities, Applications of "or", "or else" and "and" in inequalities. Sets of Real numbers: Positive integers, Integers, Rationals, Irrationals, Rationals and Irr ationals as dense sets (without proof), Bounded sets, Intervals, Geometric representations. Modulus: Definition, Modulus and distance, Properties of modulus, Inequalities, Solution sets

Real functions: Basic idea of a function and various ways of expressing functions, Domain and range, Algebra of functions, Image and inverse image (of a Set), Bounded functions, Important examples (Polynomials, rational functions, trigonometric functions), Composition of functions, 1-1 functions, onto functions and bijections, Inverse functions, Monotonic functions, Inverse trigonometric functions. Finite Limits and continuity of functions defined on a finite union of intervals: Intuitive idea of a limit, Left limit, right limit and limit (at an interior point or an end point), Algebra of limits (without proofs), Limits of composite functions (without proof), Left continuity, right continuity and continuity (at a point) and related results, Continuous functions and continuity on an interval, Intermediate value theorem and Max, Min value theorem (without proofs), Definition of the n^{th} root function as the inverse function of $y=x$, Rational power of a positive number.

Infinite Limits: The intuitive idea of different types of infinite limits, Graphical illustrations (Asymptotes), Algebra of both finite and infinite limits.

Differentiability: Intuitive idea of a derivative, Left derivative, right derivative and derivative (at an interior point or an end point) in terms of limits, Algebra of derivatives and chain rule with proofs using algebra of limits, Derivative of an inverse function (without proof), Differentiability and continuity, Differentiable functions and a function being differentiable on an interval, Mean value theorem (without proof) and applications in monotonicity and extremum points. Connection between critical point and extremum points. Higher order derivatives and their application in maxima, minima and concavity.

Method/s of Evaluation:: End of semester examination.

Suggested References:

- *Calculus and Analytical Geometry by G B Thomas and R L Finney (8^{th} Edition)*

PM 1002 Algebra 30L (2C)

Rationale: *This course unit introduces fundamental notions in algebra, with an introduction to abstract algebra*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to:

- *Define a group, Abelian group, cyclic group, subgroup, normal subgroup, cosets, normal subgroup and quotient group, and give examples.*
- *Describe the divisibility of numbers and solve problems in modulo arithmetic, including the use of Euclidean algorithm.*
- *Describe mathematical structures, including matrices, Z/nZ and permutation, in terms of groups.*
- *Use basic properties of groups to solve problems, including congruences, permutations and symmetries of regular polygons.*
- *Describe and give examples of subgroups, normal subgroups and cosets.*

- *Prove Lagranges theorem and use it to solve problems.*

Course Content:

Sets: Notation, containment and equality, intersection, union, empty set, Cartesian product. Complex Numbers: Fundamental operations on the complex numbers, complex conjugate, modulus, Argand diagram, polar representation, de Moivre's theorem, roots of unity, some simple transformations of the complex plane – translations, rotations and magnifications. Matrices: Matrices over R and over C, Special types of matrices – zero and identity matrices, triangular and diagonal matrices, symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices, and orthogonal matrices; Matrix operations, Singular and non-singular matrices, The inverse of a square matrix, evaluation of the inverse of a 2 x 2 matrix. Elementary Number Theory: The division algorithm, Greatest common divisor, The Euclidean algorithm, Prime factorization theorem in N, Congruences, Modulo arithmetic Zn. Generalized notion of a function. Binary Operations: Definition, examples, basic properties. Group Theory: Definition of a group, Examples including the nth roots of unity under multiplication, matrices under addition, non-singular matrices under multiplication, Abelian and non-abelian groups, Subgroups, Statement of Lagrange's theorem, Definition of a homomorphism, examples and basic properties.

Method/ s of Evaluation: End of semester examination

Suggested References:

- *Algebra, Michael Artin, Second Edition, Pearson Education Limited, 2013*
- *Basic Abstract Algebra, P. B. Bhattacharya, S. K. J ain, S. R. Nagpaul*
- *Burton, D. M., Elementary number theory, 2011 - McGraw-Hill - New York*

PM 1004 Sets and Combinatorics (30L, 2C)

Rationale: *To study mathematics in the physical science streams at the Science Faculty of University of Colombo students have to know the methods of proofs and their logical foundation, the difference between axiomatic approaches and the naïve approach in set theory, and essential set theoretic concepts. As the thirteen years of learning mathematics at school including GCE Advanced Level Combined Mathematics does not provide this knowledge this course provides it. Also, this course introduces students to more advanced counting techniques and concepts in Combinatorics than the ones they learned in Combined Mathematics. These concepts and techniques are useful in advanced mathematics courses.*

Prerequisites: *None*

Intended Learning Outcomes: *By the end of the course, students should be able to:*

- *Explain and use different methods of proofs in mathematics,*
- *Explain the difference between axiomatic approaches and the naïve approach in set theory,*
- *Explain and use essential set theoretic concepts, and*

- *Explain and use concepts and advanced counting techniques in Combinatorics.*

Course Content:
Methods of Proofs: If, iff, method of contradiction, counter examples.
Sets: Definitions and Notations, Subsets, Equality, Universal set, Power set, Set Operations, Algebra of sets, Proofs of results using labelled Venn diagrams, Algebric proofs of results.
Combinatorics: Applications of mathematical induction, Basic principles of counting, Permutations and combinations, Generalized permutations and combinations, Application of Permutations, Combinations and generalized permutations, Pigenholes principle, Binomial coefficient's and combinatorial identities, Generating functions and applications of Generating functions, Algorithms for generating permutations and combinations, Applications of permutations and combinations in Graph Theory, Counting concepts in graph theory and other areas.

Method/ s of Evaluation: *End of semester examination (at least 70%) and Continuous assessment (at most 30%) and these two components add up to 100%*

Suggested References:
- *Elements of Advanced Mathematics by Steven G. Krantz*
- *Applied Combinatorics by Alan Tucker*

AM 1001: Differential Equations I (30L, 2C)

Rationale: *This course unit is introduced to provide an introduction and overview of ordinary differential equations and their solutions.*

Prerequisites: *None*

Intended Learning Outcomes:
By the end of the course, students should be able to
- *describe the meaning of an ordinary differential equation.*
- *find general solutions of first order and second order ordinary differential equations.*
- *model real world processes with initial/boundary value problems.*
- *solve real world initial/ boundary value problems and interpret solutions.*

Course Content:
Ordinary Differential Equations with examples: Particular solution, general solution, singular solution, complete primitive; Remark on existence of solution; First Order First Degree equation; Singular points. Introduction of the Differential. Special types of ODE's of the first order Separable ODE's, Exact equations. Integrating Factor, Bemoulli's, Riccati-type equations. Orthogonal trajectories; Linear equations of the first order; Linear equations of the second order with constant coefficients; Complementary function, particular integral; Euler's homogeneous form of the second order.

Method/ s of evaluation: End of semester examination.

Suggested References:
- *Differential equations and their applications by Martin Braun, 4th edition*

AM 1002: Vectors (30L, 2C)

Rationale: *This course unit provides fundamental knowledge for solving some applied problems in Physical Science.*

Prerequisites: *None*

Intended Learning Outcomes:

- *Solve algebraic, differentiation and integration vector problems;*
- *calculate physical quantities such as flux, divergence, curl;*
- *use Stoke's theorem, Green's theorem for integrals.*

Course Content: *Introduction; vectors, scalars; properties of vectors; scalar, vector, triple scalar and triple vector products; geometrical applications (equations of a line, plane, etc.). Differentiation of vectors; geometric interpretation of the derivative; gradient of scalarfunctions; geometrical interpretation of grad ϕ; the divergence and curl of the vector and double operators; physical interpretation of irrotational and solenoidal vector fields. Integration of vectors; line integrals, surface and volume integrals; Divergence theorem, Stoke's theorem, Green's theorem.*

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *3D Vectors: Algebra, Differentiation and Integration, 2nd edition, A.D.W. Karunatilleke, T. Golochtchapova, ISBN 978-955-671-058-8, 2012.*
- *Introduction to Vector Analysis, Harry F. Davis, Arthur David Snider, 1992.*
- *Schaum's Outline of Theory and Problems of Vector Analysis and an Introduction to Tensor Analysis, Murray R. Spiegel, Schaum's Outline Series, McGraw-Hill, Inc., ISBN07- 060228X*

AM 1003: Matrices (30L, 2C)

Rationale: *This course unit provides an introduction and overview of 'matrices' and highlights its usefulness in solving various types of problems that arise in Mathematics and the Sciences.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *manipulate matrices and recognize special types of matrices*
- *solve systems of linear equations using different methods*
- *compute determinants and know their properties*
- *determine the eigen values of a matrix and the corresponding eigen vectors*

- *solve certain systems of differential equations and determine the standard form of conics using eigen values and their corresponding eigen vectors*

Course Content: *Introduction, various types of matrices, matrix algebra, inverse, transpose of a matrix and its properties; Matrix expression of a system of linear equations, row operations, augmented matrix, Gaussian method. Determinants, minors, cofactors, properties of a determinant, cofactor and adjoint matrices; Cramer's rule for matrix solutions. Characteristic polynomial, characteristic values (eigen values) and vectors; Cayley Hamilton theorem. Matrix special function e^A. Similar matrices, diagonalization and their applications. System of differential equations, matrix representation of conics. Special determinants and matrices (the Jacobian, the Hessian, the Discriminant).*

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Linear Algebra and its Applications by G. Strang*
- *A Textbook of Matrices by S. Narayan*

AM 1005 GRAPH THEORY 30L (2C)

Rationale: *This course unit is introduced to provide an introduction to Graph Theory*

Intended Learning Outcomes:

- *solve problems in graph theory.*
- *understand how graph theory is used to store data in computer memory.*

Course Content:

Introduction to graphs; Subgraphs; Paths; Connectivity of graphs; Cycles; Complete, regular and bipartite graphs. Tree graphs: Binary trees, binary search trees, representing binary trees in memory; Prefix and postfix forms of an expression; Isomorphic and homomorphic graphs; Representing graphs in the computer memory.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Introduction to Graph Theory (Pearson): Douglas West*
- *Graph Theory with Applications (Elsevier): Bondy and Murty*
- *Graph Theory (Springer): Reinhard Diestel*
- *Graph Theory (Sarasavi): Jayawardene*

AM 1006: Geometry with Applications (30L, 2C)

Rationale: *This course unit is introduced to provide an overview of techniques and methods of analytical geometry that enable students to solve geometrical problems.*

Prerequisites: *None*

Intended Learning Outcomes:

- *Learn basic properties of conics and quadratic surfaces,*
- *Learn classification of quadratics.*

Course Content: *Analytical Geometry $E_2(R)$: rectangular Cartesian coordinates in E_2 ; parabola, ellipse, hyperbola, directrix, focus, eccentricity e; general conic and translation of axes; rotation of axes; classification of central conics, non-central conics. Analytical Geometry $E_3(R)$: rectangular Cartesian coordinates in E_3 ; equations of lines, planes; direction cosines and change of axes; translation and rotation; sphere. Quadratic as a second-degree equation $S \equiv ax^2 + by^2 + cz^2 + 2fyz + 2gzx + 2hxy + 2ux + 2vy + 2wz + d = 0$. Central quadratic $S \equiv ax^2 + by^2 + cz^2 + 2fyz + 2gzx + 2hxy + d = 0$ and its matrix representation. Non-central quadratics, classification of quadratics. Introduction to polar, spherical, cylindrical coordinate systems.*

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Schaum's Outline of Theory and Problems of Plane and Solid Analytic Geometry, McGraw-Hill, Inc., ISBN 07-034575-9*
- *Analytic Solid Geometry, Dipak Chatterjee, Prentice Hall of India Pvt Ltd, 2003, ISBN-81-203-1918-4.*

AM 1008: Mathematics for Biological Science

Rationale: *This course is to introduce the basic mathematics applications in Biology and Chemistry.*

Prerequisites: None.

Intended Learning Outcomes:

Upon completion of the course, students should be able to:

- *Understand and apply the basic mathematical concepts, notations and their properties: sets and their operations, numbers and law of indices, absolute value and their inequalities, different types of functions, vectors and Matrices.*
- *Solving quadratic and simultaneous linear equations.*
- *Represent complex numbers algebraically and geometrically.*
- *Finding the inverse of a function, composition of two functions and even, odd functions, and limit of a function.*

- *Apply differentiation and integration techniques on functions with one variables.*
- *Computation of first and higher order partial derivatives on functions with two or three variables.*
- *Formulate and solve problems from mathematical and everyday situations.*

Course Content:

Basic Algebra: Elementary set theory, Numbers and law of indices, Exponential, Logarithmic and natural logarithmic functions. Solving quadratic and simultaneous linear equations. Introduction to complex numbers.

*Basic Trigonometry**:** Trigonometric functions and their inverse functions. Graphs of Sine, Cos and Tan functions. Various identities with trigonometric functions.*

Basic Coordinate Geometry: Equation of a straight line, gradient and intercept of a straight line.

*Vectors and Matrices**:** Addition, Scalar multiplication and dot products of vectors. Addition, scalar multiplication, multiplication and transpose of matrices. Determinants and inverse of square matrices.*

Calculus: Limit, Differentiation -derivatives of algebraic, exponential and logarithmic functions, trigonometric functions, and inverses of trigonometric functions. Introduction to partial differentiation, Graphical interpretations of derivatives, Maxima and Minima. Integration. Linear first order and second order differential equations.

Statistics: Elementary sampling methods, data presentation and simple analyses: Elementary probability theory. Introduction to simple linear regression.

Method/ s of Evaluation: *End of Semester Examination.*

Suggested References:

- *Mathematics for Chemistry and Biology- Course Guide (Open University of Sri Lanka).*
- *Basic Mathematics for Chemistry by Peter Tebutt.*
- *Mathematics for the Biological Sciences by J. C. Arya.*
- *Introduction to Calculus for the Biological and Health Science by R. D. Gentry.*

FM 1001 Financial Mathematics (20L, 20P, 2C)

Rationale: *This course explores the theoretical aspects of finance and valuation of money and provides simple applications.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *explain basics valuation method*
- *identify the impotency of time value concept*
- *value the different cashflows*
- *identify different financial instruments and their features*
- *apply techniques to price the financial instrument*

Course Content:

Interest rate, Simple and Compound interest rate, Time value of Money, Present value, Future value, Discounting, Compounding, Effective rate of return (EAR), Basic annuity valuation, Annuity immediate, Annuity due, Perpetuity, Discounted cash flow analysis, NPV, Bond valuation, Loan repayment methods, Internal rate of return (IRR), interest rate on fund, Excel financial functions and their applications.

Method/ s of Evaluation: *End of semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *Ross, SA, Westerfield, RW, Jordan, BD, (2002), Fundamentals of Corporate Finance, 8th edition, McGraw-Hill Publishing Company.*
- *Kellison, SG, (2008), The Theory on Interest, 6th Edition, Richard D. Irwin Inc.*

FM 1002 Mathematical Methods for Finance I (30L, 2C)

Rationale: *This course unit is introduced to provide an introduction and overview of essential mathematical methods useful for solving real-world problems.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Explain the concept of solution of an ordinary differential equation*
- *Model real-world problems through differentialequations*
- *Solve elementary first and second order ordinary differential equations and difference equations*
- *Compute partial derivatives of functions*
- *Evaluate the eigenspectrum of a given square matrix*
- *Apply digonalisation methods to simplify hard matrix operations*

Course Content:

Expected learning outcomes: Fundamentals of Mathematical methods in the sense of financial applications. Introduction, Ordinary Differential Equations with examples in financial

applications (first order ordinary differential equations: Differentials, Classical solution methods, second order constant coefficient ordinary differential equations). Introduction to first and second order constant coefficient difference equations, classical solution methods, application in finance. Solving systems of linear difference equations.

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Kreyszig, E., 2010. Advanced Engineering Mathematics. John Wiley & Sons.*

FM 1004 Mathematical Economics (30L, 2C)

Rationale: *This course unit is intended to give an overview of mathematical applications in economics.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of the course students are expected have a good knowledge of*

- *Basic micro and macro economic models*
- *Ability to analyse and extend the models they studied.*

Course Content:

Introduction to Economics, Role of mathematics in economics, General study of demand, supply and equilibrium. Static analysis of market models and selected macro economic models. Effect of taxation on static market, models. Dynamic analysis in continuous and discrete time of market models and selected macro economic models. Effect of taxation on dynamic market models. Elasticity and other economic concepts: elasticity of demand and supply point and cross elasticities. Analysis of single product functions and joint products functions {cost, revenue, profit, etc.}. Consumer's and Producer's surpluses. Optimisation of single product functions and joint products functions {cost, revenue and profit functions}. Utility functions: introduction, derivation, maximizing with and without budget constraints; derivation of demand functions, marginal rate of substitution, indifference curves and contract curves (Edgeworth box).

Method/ s of Evaluation*: End of semester examination*

. ***Suggested References****:*

- *Fundamental Methods of Mathematical Economics by Alpha C Chiang. Third Edition McGraw HillInc.*
- *Introductory Mathematics for Economics and Business by K Holden and A W Pearson. Second Edition McMillan Press.*

FM 1005 Linear Algebra (30L, 2C)

Rationale: *The goal of this course is to understand required basic concepts of Matrices, Vector Spaces and Linear Transformations to solve system of Linear Equations*

Prerequisites: *None*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Understand set theory*
- *Understand functions and relations*
- *Identify different types of Matrices*
- *Understand properties of Matrices*
- *Determine eigenvalues, eigenvectors and understand diagonalization*
- *Solve system of linear equation*
- *Understand row echelon form and reduced row echelon form*
- *Apply Gaussian Elimination Process to solve system of linear equations*
- *Calculate inverse of a matrix using row operations*
- *Find rank and determinant of Matrices.*
- *Understand definition of Vector Spaces, examples and related Theorems.*
- *Understand Subspaces*
- *Identify the given set is linearly independent or linearly dependent*
- *Identify the given set spans a vector space.*
- *Understand a basis of a Vector Space and to determine dimension of a Vector space.*
- *Determine rank and a nullity of a Vector space*
- *Understand Linear Transformation of Vector spaces*
- *Understand Inner product spaces, Orthogonality, Orthogonalization process.*

Course Content:
Sets and functions: Set operations, set operations, Venn diagrams, Domain and range, Inverse and composition.

Vectors, Matrices and determinants: System of linear equation, Solutions to system of linear equations, Matrices, Rank, Determinants, Non-singular matrices. Vector spaces subspaces, Nullspace, Basis and dimension. Linear transformation, change of basis. Matrix representation of a linear transformation, Eigenvalues I Eigenvectors, Diagonalization, Inner products, Orthogonality, Orthogonalization process.

Method/ s of Evaluation : *End of semester examination*

Suggested References:

- *Kenneth Hoffman, Linear Algebra*
- *D.S.Malik, John M. Mordeson, M.K. Sen, Fundamentals of Abstract Algebra.*

MS 1002 Linear Programming (20L, 20P, 2C)

Rationale: *The goal of this course is to formulate, analyse and solve mathematical (linear) models for real-life optimal decision problems.*

Prerequisites: *Linear Algebra*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Develop a fundamental understanding of linear programming models.*
- *Able to develop a linear programming model from problem description.*
- *Apply the Graphical and Simplex methods for solving linear programming problems.*
- *Study the effect on optimal solution of the LP model due to variations in the input parameters (Sensitivity Analysis).*
- *Able to solve LP problems using TORA program.*

Course Content:

Formulation of linear programming problems, Solving two variable LP problems using the graphical method. The Simplex algorithm. The Simplex method in matrix notation. The degeneracy and convergence of the Simplex algorithm. Sensitivity and parametric analysis. The Dual Simplex method, Big M method and the Two Phase Simplex method.

Method/ s of Evaluation: *In class test, practical test and end of semester examination*

Suggested References:

- *H.A. Taha, Operations Research, 8th / 10th Editions 2009/ 2017, Pearson Prentice Hall.*
- *W.L. Winston, M. Venkataramanan, Introduction to Mathematical Programming, 4th Edition 2003, Brooks/Cole, Cengage Learning*
- *3.F. S. Hillier and G. L. Lieberman, Introduction to Operations Research, 9th Edition 2010, McGraw-Hill, New York.*

MS 1004 Computing For Finance (10L, 10P, 1C)

Rationale: *This course unit is introduced to provide an overview of MATLAB and use it in computing for finance.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *use MATLAB in financial computations*
- *compute portfolio parameters such as returns, risks, optimal weights.*

Course Content:

Use of computer software packages like MatLab to maximize/ minimize functions subject to certain constraints. Use of or Java to analyze and solve specific problems that come up in areas like Management, Finance, Economics and Applied Mathematics, in general. Computer applications of Optimization techniques in solving and analyzing problems.

Method/s of Evaluation: *End semester Examination.*

Suggested References:

- *Introduction to MATLAB for Finance,(2009@Mathworks inc.)*

PM 2001: Calculus II (30L, 2C)

Rationale: *This course unit is introduced to offer a theoretical understanding of further topics in calculus which were not covered in PM 1001.*

Prerequisites: PM *1001*

Expected learning outcomes:

By the end of the course, students should be able to

- *Describe anti-derivatives*
- *Evaluate integrals by integration techniques*
- *Determine convergence\divergence of series using standard tests*
- *Define logarithmic and exponential functions*
- *Compute the series representations of functions*
- *Differentiate and integrate power series*
- *Describe intervals and radii of convergence*

Course Content:

The definite integrals of continuous functions: Area under a curve, definition of a definite integral, basic results, Anti-derivatives, Fundamental theorem of Calculus, Mean value theorem for integration, Definition of logarithm and exponential functions, Techniques of integration, Numerical methods.

Sequences: Definition and examples, Sequences given by recursions, Bounded sequences, Algebra of sequences, limit of a sequence (intuitive idea) and algebra of limits, Convergence and divergence of a sequence. Convergence of monotonic bounded sequences (without proof).

Series: Sequence of Partial sums, Definition of convergence, Absolute and conditional convergence, Geometric series, Test for divergence, Alternating series, Series of positive numbers (comparison tests, ratio test, root test, integral test), convergence of p series and its applications in comparison test.

Power Series: Radius of convergence and interval of convergence, Differentiation and integration of power series (without proof) and applications, Taylor's and Maclaurin's series and L'Hospital's rule, Series representation of exponential, logarithm and trigonometric functions.

Method/s of Evaluation: *End of semester examination.*

Suggested References:

- *Principles of Mathematical Analysis, Walter Rudin, 3rd Edition*
- *Mathematical Analysis, Tom M. Apostol, 2nd Edition*
- *PEU 4300 Unit I Sequences (Open University Publications)*
- *PEU 4300 Unit II Series (Open University Publications)*
- *PEU 4301 Unit I Continuous Functions (Open University Publications)*
- *PEU 4301 Unit II Differentiable Functions (Open University Publications)*

PM 2002: Linear Algebra (30L, 2C)

Rationale: *This course unit introduces foundations of linear algebra.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to:

- *Define basic concepts in linear algebra including concepts related to vector spaces, linear transformations and inner product spaces.*
- *Understand the main ideas in basic theorems, including the theorem on the dimension of a sum and rank nullity theorem.*
- *Apply these notions to solve problems in R^n and give geometric interpretations.*
- *Perform relevant computations, such as to determine dimensions and bases, and analyze the implications of the results.*
- *Describe and apply Gram Schmidt procedure and use it in computations.*

Course Content:

Matrices: Rank of a matrix, computation of the rank of matrices using elementary row-operations. Vector spaces; Subspaces; Intersections and sums of subspaces; Spanning sets and bases; Dimension of a vector space and dimension of a subspace; Dimension of the sum and the intersection of Subspaces. Linear Transformations: Algebra of linear transformations; Kernel and range; Linear transformations on finite dimensional spaces -bases and coordinate systems, matrices and linear transformations, kernel and range; Similarity and change of bases -transition matrices and similar matrices. Eigen values and Eigen vectors: Basic ideas; Finite dimensional spaces; Diagonalisable linear transformation and direct sum decompositions; Powers of diagonalisable matrices. Orthogonal projections: Basic ideas; Gram Schmidt procedure to find an orthonormal basis; Projection matrices. Orthogonal and symmetric matrices: Orthogonal matrices and orthogonal change of basis; Symmetric matrices and diagonalizing symmetric matrices; Bilinear forms; Quadratic forms and change of basis. Introduction to inner product spaces. All topics given above should contain less theory but

more application and problems.

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Linear Algebra, Kenneth M Hoffman, Ray Kunze, 2nd Edition*
- *Linear Algebra Done Right, Sheldon Axler, 3rd edition*

PM 2004: Logic and Introductions to Analysis (30L, 2C)

Rationale: *This course unit is introduced to provide the logic needed to study mathematics and the logical meanings of the basic concepts of Analysis.*

Prerequisites: *PM 1001 and PM 2001*

Intended Learning Outcomes:

By the end of the Course, students should be able to:

- *Explain the logical meanings of the five logical connectives and the two quantifiers*
- *Write the negation of a given statement*
- *Prove or disprove a simple statement in mathematics*
- *To use the method of conditional proof, proof by contraposition and proof by contradiction to prove a conditional statement*
- *Define a relation, a function, an injection, a surjection, a bijection and an inverse of a function*
- *Define a bounded/unbounded set of real numbers, maximum, minimum, upper bound, lower bound of a set of real numbers, supremum and infimum of a set of real numbers*
- *Use the completeness axiom in the solutions of problems on supremum and infimum*
- *Define a sequence, bounded or unbounded sequence, convergent or divergent sequence and analyze the properties ofsequences*
- *Define limit point of a set of real numbers*
- *Define limit of a function at a limit point of its domain*
- *Determine the left continuity, right continuity and continuity of a function at a limit point of its domain*
- *Define infinite limits of a functions*

Course Content:

Logic: Propositions, Predicates and propositional variables, Truth tables, Tautologies and contradictions, Arguments involving variables, Basic quantifiers. '

Relations and functions: Ordered pairs, Cartesian product, Relations, Range and domain, Image of a set under a relation (image of union, intersection and difference of sets), Restriction of a relation on a subset of the Domain, Inverse of a relation, Composition of relations, Functions, Injections, surjections and bijections, Inverse functions.

Bounded and unbounded sets of real numbers: Maximum and minimum, Upper and lower bounds, Axiom of completeness of real numbers, Supremum and infimum, Limit points of a set.

Sequences: Bounded and unbounded sequences, Convergence of a sequence, Boundedness of a convergent sequence, Algebra of limits, Sandwich theorem, Convergence of monotonic sequences

Limits and continuity of a function: Formal definition of left limit, right limit and limit at a limit point, Uniqueness of limits, Algebra of limits, Limits of composite functions, Limit of a function in terms of sequences, Formal definition of left continuity, right continuity and continuity, Formal definition of infinite limits, Intermediate value theorem.

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Mathematical Analysis, Tom M. Apostol, 2nd Edition*
- *PEU 3300 Unit I Mathematical Logic (Open University Publications)*
- *PEU 3300 Unit II Mathematical Proofs (Open University Publications)*
- *PEU 3301 Unit I Algebraic Structure of the Foundations of Mathematics (Open University Publications)*
- *PEU 3301 Unit II Analytic Structure of the Foundations of Mathematics (Open University Publications)*
- *PEU 4300 Unit I Sequences (Open University Publications)*
- *PEU 4300 Unit II Series (Open University Publications)*
- *PEU 4301 Unit I Real Analysis I (Open University Publications)*

AM 2001: Differential Equations 11 (30L, 2C)

Rationale: *This course is to introduce second order ordinary differential(variable coefficient) and difference equations for modelling physical and other phenomena.*

Prerequisites: AM *1001*

Intended Learning Outcomes:

Upon completion of the course, students should be able to:

- *Solve ordinary differential equations of linear second order with variable coefficients*

using analytical methods.

- *Find power series solutions of above type differential equations.*
- *Finding the ordinary, singular, regular singular and irregular singular points.*
- *Solve first and second order linear difference equations.*
- *Investigate the qualitative behavior of the above differential and difference equations.*
- *Analyse and model real life problems using above analytical methods.*

Course Content:

Ordinary differential equations: Linear equations of the second order where the coefficients are functions of the independent variable; Ordinary points; Singular points; Regular singular points; Solution in series; Stability of the solutions; Solution of Laplace's equation; Revision of Euler's homogeneous form of the second order ordinary differential equations; Legendre's equation; Legendre's polynomials their linear independence and recurrence relations; Bessel's function. Introduction to Difference equations: Complementary functions and particular solutions.

Method/ s of Evaluation: *End of Semester Examination.*

Suggested References:

- *Elementary Differential Equations (seventh edition) by Boyce -DiPrima.*
- *Differential Equations (Third edition) by Shepley L. Ross.*
- *Introduction to Difference Equations by Samuel Goldberg.*

AM 2002: Numerical Analysis I (30L, 2C)

Rationale: *This course unit is introduced to provide an introduction and overview of numerical methods and their applications.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *formulate mathematical problems to apply numerical methods.*
- *write down numerical algorithms to find approximate solutions of mathematical problems.*
- *estimate rates of convergences of and error bounds for the approximate solutions.*

Course Content:

Mathematical preliminaries for numerical analysis: Taylor's theorem and its various forms; Orders of convergence; Big O and small o; Sources of errors; Algorithms and convergence. Solutions to non-linear equations: Bisection method; Fixed, point iteration; Newton-Raphson

method; Error analysis for iterative methods. interpolation and curve fitting: Least square approximation; Polynomial interpolation; Lagrange polynomial; Divided differences; Hermite polynomial; Introduction to spline interpolations. Numerical differentiation and integration: Numerical differentiation; Richardson's extrapolation; Elements of numerical integration; Composite integration; Romberg integration; Adaptive quadrature methods; Gaussian quadrature. Initial value problems for ordinary differential equations. Elementary theory of initial value problems; Euler's method; Higher order Taylor methods; Runge-Kutta methods.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Numerical Analysis by Richard A. Burden and J . Douglas Faires,9th edition*
- *Numerical Mathematics and Computing by Ward Cheney and David Kincaid,6th edition.*

AM 2003: Linear Programming (30L, 2C)

Rationale: *The goal of this course is to formulate, analyse and solve mathematical (linear) models for real-life optimal decision problems.*

Prerequisites: *Linear Algebra*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Develop a fundamental understanding of linear programming models.*
- *Able to develop a linear programming model from problem description.*
- *Apply the Graphical and Simplex methods for solving linear programming problems.*
- *Study the effect on optimal solution of the LP model due to variations in the input parameters (Sensitivity Analysis).*

Course Content: *Introduction to mathematical modelling and operational research. Formulation of linear programming models; Assumption of the model; Standard form; General model; Matrix representation. Graphical solution to linear programming problems and sensitivity analysis; Introduction to simplex algorithm; two-phase method (2 variables only). Interpolation of final tabular; Applications of linear programming in various fields.*

Method/s of Evaluation: *End of semester examination.*

Suggested References:

- *H.A. Taha, Operations Research, 8^{th} / 10^{th} Editions 2009/ 2017, Pearson Prentice Hall.*
- *W.L. Winston, M. Venkataramanan, Introduction to Mathematical Programming, 4^{th} Edition 2003, Brooks/Cole, Cengage Learning*
- *3.F. S. Hillier and G. L. Lieberman, Introduction to Operations Research, 9^{th} Edition 2010, McGraw-Hill, New York.*

AM 2004: Optimization (30L, 2C)

Rationale: *The goal of this course is to formulate, analyse and solve optimization models for real-life optimal decision problems.*

Prerequisites: AM *2003*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Able to use Additional Simplex Algorithms to solve general LPs.*
- *Able to use the Duality Theory to solve LP problems.*
- *Able to carry out the Post Optimal Analysis.*
- *Develop a fundamental understanding of Non-linear Programming models.*
- *Able to formulate, analyse and solve Unconstrained and Constrained optimization problems.*
- *Develop a fundamental understanding of Theory of Games.*

Course Content:

Simplex algorithm; Two-phase method and Dual simplex methods (for more than two variables); Duality theorem; Sensitivity analysis in detail. Unconstrained and constrained optimization of functions of single and many variables and applications. Introduction to game theory.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *H.A. Taha, Operations Research, 8th / 10th Editions 2009/ 2017, Pearson Prentice Hall.*
- *W.L. Winston, M. Venkataramanan, Introduction to Mathematical Programming, 4th Edition 2003, Brooks/Cole, Cengage Learning*
- *F. S. Hillier and G. L. Lieberman, Introduction to Operations Research, 9th Edition 2010, McGraw-Hill, New York.*

AM 2005: Differential Equations III (30L, 2C)

Rationale: *This course is to introduce systems of first order differential equations and fundamentals of partial differential equations and apply these for modelling physical and other phenomena.*

Prerequisites: *AM 1001, AM 2001*

Intended Learning Outcomes:

Upon completion of the course, students should be able to:

- *Develop the ability to apply systems of first order differential equations to scientific problems.*
- *Compute the characteristic polynomial, eigenvalues and eigen space, eigen vectors as well as the geometric and algebraic multiplicities of an eigen value and apply it to find the solutions of systems.*
- *Investigate the qualitative behavior of the systems differential equations.*
- *Classification of partial differential equations and solve linear PDE's using Separation of variables method.*

Course Content:

Ordinary differential equations: Transformation of higher order ordinary differential equations with constant coefficients to a system of first order ODE' s; Fundamental solution, Qualitative theory of ODE' s (stability of linear systems). Partial differential equations: Functions of several variables, partial differentiation; First and second order linear PDE's with constant coefficients; Classification; Solution by separation of variables; Heat equation, wave equation, Poisson equation, Laplace equation.

Method/ s of Evaluation: *End of Semester Examination.*

Suggested References:

- *Elementary Differential Equations (seventh edition) by Boyce -DiPrima.*
- *Differential Equations (Third edition) by Shepley L. Ross.*
- *Advanced Engineering Mathematics by ErwinKreyszig.*

FM 2001: Computational Financial Mathematics I (20L, 20P, 2C)

Rationale: *This course is to introduce fundamentals of numerical analysis used in Finance and fundamentals of amortization schedules, sinking funds, bonds andother securities*

Prerequisites: None.

Intended LearningOutcomes:

Upon completion of the course, students should be able to:

- *Compute the numerical errors and the rates of convergence.*
- *Apply the iterative methods (such as Bisection, Secant, Newton-Raphson) to solve non -linear equations.*
- *Construct polynomial approximations to functions byinterpolation methods.*
- *Use spline techniques for curve fitting.*
- *Analyse and model applications in finance using numerical methods.*
- *Use MATLAB to implement numerical algorithms*

- *Create an amortization schedules and sinking funds*
- *Understand the knowledge on loan repaying methods, valuation of bonds and other securities.*
- *Understand how the concepts on theory of interest can be applied for valuation and pricing.*

Course Content:

Elementary Numerical methods and applications. Introduction to numerical methods, Taylor's Theorem and its Various forms. Different forms of numerical errors, orders of approximations, solution of non-linear equations and their applications in finance, interpolation techniques; polynomial interpolations, introduction to splines. Amortization schedules and Sinking funds: outstanding principal, amortization schedules, sinking hands, differing payment / interest conversion periods, varying series of payments. Bonds and other securities: types of securities, price of a bond, premium/ discount, coupon payments, callable bonds, serial bonds, valuation of securities.

Method/ s of Evaluation: *End of Semester Examination.*

Suggested References:

- *Numerical Methods for Mathematics, Science and Engineering by John H.Mathews.*
- *Elementary Numerical Analysis by Kendall Atkinson.*
- *Mathematical Interest Theory, Second Edition by Leslie Jane Federer Vaaler and James Daniel.*
- *Financial Mathematics- A practical Guide for Actuaries and other Business Professionals, Second Edition by Ruckman and Francis.*
- *Mathematics of Investment and Credit, Fifth Edition, by Samual A. Broverman.*

FM 2002 Actuarial Mathematics I (30L, 2C)

Rationale: *This course explores the theoretical aspects of random cash-flows particularly life insurance models and pricing of such models.*

Prerequisites: *FM 1001*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and concept of actuarial present value.*
- *understand differences between life insurance policies.*
- *evaluate the actuarial present value.*
- *model and compute future life time.*

- *design and compute life insurance product.*
- *practice actuarial evaluation techniques.*

Course Content:

Introduction to Actuarial concepts, valuation and actuarial valuation, importance of actuarial concepts and their applications in various finance fields, Introduction to insurance, Survival distribution, mortality rate, life expectancy, life table, Insurance and related models, Applications of insurance models, Life annuity and related models, Applications of life annuity models, Loss random variable and its applications in Insurance models, Premiums determination methods and related problems.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *N L Bowers et al (1997), Actuarial mathematics, 2nd edition, Society of Actuaries.*
- *H U Gerber (1990), Life Insurance Mathematics, Springer.*

FM 2004 Mathematical Methods for Finance II (30L, 2C)

Rationale: *This course unit is introduced to offer a theoretical understanding of solutions of differential equations and to provide an overview of mathematical methods.*

Prerequisites: *FM 1005*

Expected learning outcomes:

By the end of the course, students should be able to

- *Verify existence and uniqueness of a solution using Picard-Lindelöf theorem*
- *Solve a system of ordinary differential equations*
- *Apply Euler-Lagrange formula to solve variational problems*
- *Explain time-to-frequency conversion of functions and applications*
- *Calculate Fourier series and Fourier transformations*
- *Obtain computational results for differential equations by Picard's method*

Course Content:

Understanding of advanced topics in Mathematical Methods. Idea of well-posedness of a problem, initial/ boundary value problem (ODE), existence, uniqueness theorems (without proof) and related results,

System of ordinary differential equations, Fourier series/ transforms and their applications, calculus of variations, Introduction to stochastic differential equations.

Method/s of Evaluation: *End of semester examination*

Suggested References:

- *Simmons, G.F., 2016. Differential Equations with Applications and Historical Notes. CRC Press*
- *Kreyszig, E., 2010. Advanced Engineering Mathematics. John Wiley & Sons.*

FM 2005 Computational Financial Mathematical II (25L, l0P, 2C)

Rationale: *This course is to introduce numerical methods for solving ordinary differential equations, insurance mathematics, economic index numbers and their applications in Finance.*

Prerequisites: *FM 1003*

Intended Learning Outcomes:

Upon completion of the course, students should be able to:

- *Define numerical differentiation, errors and accuracy.*
- *Construct numerical methods to solve ordinary differential equations.*
- *Investigate the qualitative behaviour of the numerical solutions of the differential equations.*
- *Analyse and model applications in finance using numerical methods.*
- *Use MATLAB to implement numerical algorithms.*
- *Understand the basics of insurance mathematics, economic index numbers and application, and their limitations.*

Course Content:

Numerical approximation of a derivative. Numerical solutions of Ordinary differential equations. One step methods, introduction to multi-step methods, definition of consistency, stability and convergence, Insurance mathematics: utility theory, utility and insurance, optimal insurance and insurance policies. Index numbers: introduction to price, volume and value relatives, linked and chain relatives, tests for index numbers, price/ simple/ simple aggregate index numbers and their properties. Applications.

Method/ s of Evaluation: *End of Semester Examination.*

Suggested References:

- *Numerical Methods for Mathematics, Science and Engineering by John H. Mathews.*
- *Elementary Numerical Analysis by Kendall Atkinson.*
- *Actuarial Mathematics, Second Edition, by Newton L. Bowers, Hans U, Gerber, Jamee C. Hickman, A J ones and Cecil J . Nesbitt.*

MS 2002 Quantitative Methods (30L, 2C)

Rationale: *This course unit is intended to give an introduction to quantitative business models.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of the course students are expected to be able to understand basic quantitative business decision models.*

Course Content:

Arguments with Sets and Venn diagrams, Decision theory and Group Decisions: Under uncertainty various views and the study of risk, Under competition - competitive games, closed, static and dynamic models. Input output models -Leontief open and Stochastic matrices and determination of long run market shares of products Inventory management and deterministic inventory models (static and dynamic models). Equipment selection and replacement methods (static and dynamic models).

Method/ s of Evaluation*: End of semester examination*

Suggested References*:*

- *An Introduction to Management Science: quantitative approaches to decision making by D R Anderson, D J Sweeney and K Martin*

MS 2003 Qualitative Methods (15L, 1C)

Rationale: *This course unit is intended to give an introduction to qualitative business decision process.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of the course students are expected to be able to understand basic qualitative (soft OR) techniques.*

Course Content: *Discussion on Hard OR (Classical OR / Quantitative methods) and Soft OR (Qualitative methods). Introduction to Soft 0R2 Qualitative Problem Structuring Methods and Modelling interactive Decision Making processes: Strategic options development and analysis (SODA), Soft system methodology (SSM) Strategic Choice (SC), simple and hyper games, etc.*

Method/ s of Evaluation*: End of semester examination*

Suggested References:

- *Rational Analysis for a problematic world revisited: Problem structuring methods for complexity, uncertainty and conflict. by J Rosenhead and J Mingers. Second Edition John Wiley.*

PM 3001: Real Analysis (45L, 3C)

Rationale: *This course provides an introduction to Riemann integration and functions of several variables.*

Prerequisites: *PM 1001, PM 2001*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *find the supremum and infimum of a given set of real numbers.*
- *determine the existence of the Riemann Integral of a given function.*
- *evaluate a Riemann Integral using techniques of integration.*
- *apply tests for convergence of improper integrals, to determine the existence of given improper integrals.*
- *determine the limit at a point, iterated limits at a point, continuity at a point, partial derivatives and directional derivatives fora given function of several variables.*
- *construct examples of functions satisfying various conditions under Riemann integration, improper integration, limits, iterated limits, continuity, partial derivatives and directional derivatives.*

Course Content: *Preliminaries: Supremum and infimum; Uniform continuity. Riemann Integral: Darboux definition for a. bounded function on a closed interval; Necessary and sufficient condition for integrability; Integrability of monotonic functions and continuous functions; Elementary properties of the integral; Differentiation and integration (fundamental theorem of calculus); The integral as the limit of Riemann sums; Mean value theorems; Techniques of integration (integration by parts, integration by substitution). Improper integrals: Tests for convergence of improper integrals (analogues of Cauchy condition, absolute convergence, comparison test, ratio limit test, Dirichlet's and Abel's tests); Gamma and Beta functions; Wallis product and Stirling's formula; Euler's constant Functions of several variables: Limits, iterated limits, continuity; Partial derivatives (higher order partial derivatives, composition of functions and the chain rule); Directional derivative; Differentiability; Implicit functions (theorems of existence without proof); Taylor's theorem and extremum values.*

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Mathematical Analysis a straightforward approach by K.G.Binmore*

- *Calculus by M. Spivak*
- *Mathematical Analysis by S.C.Malik and S.Arora*

PM 3002: Complex Analysis (45L, 3C)

Rationale: *This course unit is introduced to provide an introduction to fundamentals of analytic function theory.*

Prerequisites: *None*

Intended Learning Outcomes: *At the end of this course, students should be able to*

- *Explain fundamental notions and results in complex analysis*
- *analyse examples and non-examples of complex functions with various properties*
- *apply properties of analytic functions, complex line integrals and series expansions to do computations and estimations that involves analytic functions*
- *formulate mathematical arguments based on basic concepts and results of complex analysis*

Course Content: *Sets of complex numbers: Open sets; Closed sets; Boundary of a set; Domains and regions. Complex functions: Conformal mappings (isometries, bilinear transformations); Limits and continuity; Polynomial and rational functions; Roots of a polynomial; Differentiability and analytical functions; Cauchy-Riemann equations. Power Series: Sequences; Series (absolute convergence, ratio and root tests); Power series; Radius of convergence; Analyticity of a power series. Elementary functions: Exponential, logarithmic and complex powers (branch cut, principal value and branches), and trigonometric functions. Integration: Curves in the complex plane; Integration on contours; The Cauchy integral theorem (without proof); Cauchy's integral formula; Taylor series; Laurent series; Zeros and poles.*

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *An introduction to Complex Analysis, Ravi P. Agarval, Kanishka Perera, Sandra Pinelas*

PM 3003: Algebra (45L, 3C)

Rationale: *This course unit provides an introduction to group theory and ring theory which are two areas of abstract algebra. Their importance lie in the abundance of examples and applications.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *demonstrate an understanding of the key concepts of a group and of a ring and provide*

examples of these structures and their substructures

- *explain the significance of the notion of a normal subgroup and an ideal*
- *use the concepts of group and ring homomorphisms and isomorphisms appropriately*
- *prove basic results of group theory and ring theory.*

Course Content: *Group Theory: Definition of a group, examples, basic properties; Subgroups; Order of an element, properties; Cyclic groups and cyclic subgroups; cosets; Lagrange's Theorem; Product of subgroups; Normal subgroups; Quotient groups; Homomorphisms; Isomorphism theorems; Permutation groups and Cayley's Theorem; Action of a group on a set. Ring Theory: Definition of a ring, examples, basic properties; Subrings; Ideals; Homomorphisms; Isomorphism theorems; Field of Quotients of an Integral Domain; Prime and Maximal Ideals; Unique Factorization Domains and Euclidean Domains; Polynomial rings.*

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Abstract Algebra by I.N. Herstein*
- *A First Course in Abstract Algebra by J .B. Fraleigh*

PM 3050: Group Theory (60L, 4C)

Rationale: *This course unit provides an introduction and overview of group theory which has wide applications and examples in mathematics and the sciences.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *use the fundamental concepts of group theory to prove basic results*
- *analyse cyclic groups and cyclic subgroups of a group*
- *explain the significance of the notion of a normal subgroup*
- *use the concepts of group homomorphism and isomorphism appropriately*
- *use Sylow's theorems to describe the structure of certain finite groups*
- *describe the structure of finite Abelian groups.*

Course Content: *Group Theory: Definition of a group, examples, basic properties; Subgroups; Order of an element and its properties; Cyclic groups and cyclic subgroups; Cosets; Lagrange's theorem; Product of subgroups; Normal subgroups; Quotient groups; Homomorphisms; Isomorphism theorems; Permutation groups and Cayley's theorem; Automorphisms and inner automorphisms; Action of a group on a set; Conjugacy classes; Cauchy and Sylow's theorems;*

Method/ s of Evaluation: *End of semester rexamination*

.***Suggested References:***

- *Abstract Algebra by D.S, Dummit and V.R.M. Foote*
- *Abstract Algebra by I.N. Herstein*

PM 3052: Real Analysis II (45L, 3C)

Rationale: *This course provides an introduction to Riemann integration, Riemann-Stieltjes integral, functions of bounded variation and rectifiable curves.*

Prerequisites: PM *3051*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *determine the existence of the Riemann Integral and evaluate a Riemann Integral of a given function.*
- *apply tests for convergence of improper integrals, to determine the existence of given improper integrals.*
- *determine whether a given function has the bounded variation property.*
- *state, prove and apply the results under Riemann I integration, Riemann-Stieltjes integration, improper integration, bounded variation, total variation rectifiable curves and arc length.*
- *construct examples of functions satisfying various conditions under Riemann integration, improper integration, Riemann-Stieltjes integration, bounded variation and total variation.*

Course Content:

Riemann Integral: Darboux definition for a bounded function on a closed bounded interval; Necessary and sufficient condition for integrability; Integrability of monotone functions and continuous functions; Linearity of the integral; Additivity of the integral over the interval of integration; Monotonicity of the integral; Integrability of composite; Integrability of the modulus and the product; Integral as a limit of a sum; Integration and differentiation; Fundamental theorem of calculus; Integration by parts; Integration by substitution; Mean value theorems; Interchanging derivative and integrals. Functions of bounded variation and rectifiable curves: Definition of bounded variation; Total variation; Additive property of total variation; Total variation on [a,x] as a function of x; Functions of bounded variations expressed as the difference of increasing functions; Continuous functions of bounded variation; Total variation as the integral of the absolute value of the derivative. Improper Riemann Integrals: Tests for convergence of improper integrals (analogues to Cauchy condition, absolute convergence, comparison test, ratio limit test, Dirichelet's and Abel's tests); Cauchy's integral test; Euler's constant; Derivation of Stirling's formula; Gamma and Beta functions. 1 Riemann-Stieltjes integral: Definition of Riemann-Stieltjes integral; Cauchy criterion for integrability; Some results on existences of integral; Additivity of integral, Integrability of monotone functions and continuous functions; Integral as a limit of a sum; Change of variable; Mean value theorem.

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Real Analysis, an introduction by A.J .White*
- *Mathematical Analysis by S.C.Malik and S.Arora*
- *A course of Mathematical Analysis by S. Narayan*
- *Mathematical Analysis by T.M.Apostal*

PM 3053: Complex Analysis (60L, 4C)

Rationale: *This Course unit is introduced to provide an introduction to fundamentals of analytic function theory of one complex variable*

Prerequisites: *None*

Intended Learning Outcomes: *At the end of this course, students should be able to*

- *Explain fundamental notions and results in the analytic function theory*
- *Understand the ideas behind the proofs of the major theorems such as Cauchy-Goursat theorem, Power series and Laurent series representations of analytic functions and Residue theorem*
- *analyse examples and non-examples of functions of complex variables with various properties*
- *apply the properties of analytic functions to make assertions about functions, series and integrals*
- *formulate mathematical arguments in the context of analytic function theory*
- *construct examples and counterexamples related to various properties of analytic functions*

Course Content:

The origin of complex numbers; The algebra, geometry and topology of complex numbers. Functions of a complex variable: Limits, continuity, analyticity and Cauchy-Riemann equations; Harmonic functions; Julia and Mandelbrot sets. Elementary functions: Exponential, trigonometric, hyperbolic and logarithmic functions; Complex powers; Contour integration; Cauchy-Goursat theorem Cauchy' s integral formula; Morera's theorem; L1ouv1lle's theorem; Maximum modulus principle; Taylor and Laurent series; Zeros and singularities; Residue theorem; Evaluation of trigonometric and improper integrals; Argument principle; Rouche' s theorem; Open mapping theorem; Conformal mappings.

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Complex Analysis, Eberhad Freitag and Rolf Busam, Springer Universitext*
- *An Introduction to Complex Function Theory, Bruce P. Palka, Springer*
- *Undergraduate Texts in Mathematics, Springer*
- *Complex Analysis, Joseph Bak and Donald J . Newman, Springer Undergraduate Texts*

in Mathematics

- *Complex Analysis, Princeton lectures in Analysis 3 by Elias M. Stein and Rami Shakarchi, Princeton University Press*

PM 3054: Topology I (45L, 3C)

Rationale: *After studying mathematics for two years students need to know advanced set theoretic concepts and cardinality of infinite sets to specialize in pure mathematics, applied mathematics or financial mathematics. They also need to have basic knowledge in metric spaces. Metric spaces provide more general techniques and insights in real analysis and complex analysis. This course provides this required knowledge.*

Prerequisites: *Knowledge of methods of proofs, essential set theoretic concepts and basic logic.*

Intended Learning Outcomes: *By the end of the course, students should be able to:*

- *Explain and use advanced set theoretic concepts,*
- *Explain and use the cardinality of infinite sets, and*
- *Explain and use basic concepts in metric spaces.*

Course content:
Advance set theory: The axiom of choice, Families of sets and their union and intersections, Generalized product of sets, Equivalence relations and equivalent classes, Ordered sets, Order preserving mappings, Trance infinite induction, Zorn's Lemma, The well-ordering principle, Ordinal and Cardinal numbers. Cardinality of a set.
Metric spaces: Definition and examples, Open and closed sets and their properties, Interior points, Point of closure, Limit points, Isolated points, Interior, closure and boundary of a set. Dense sets, Bounded sets, Distance between a point and a set. Distance between two sets, Diameter; Subspaces, Neighbourhoods, Bases, First countability, Second countability; Equivalent metrics, uniformly equivalent metrics.
Limits and Continuity: Sequences and functions in a metric space, Limit of a sequence, Limit of a function, Continuity and related results, Homeomorphisms;

Method/ s of Evaluation: *End of semester examination (at least 70%) and Continuous assessment (at most 30%) and these two components add up to 100%.*

Suggested References:

- *Topology A First Course by James R. Munkres*
- *Principles of Mathematical Analysis by Walter Rudin*
- *Introduction to Topology Pure and Applied by Colin Adams and Robert Franzosa*
- *Introduction to Topology and Modern Analysis by George F. Simmons*

PM 3055: Topology II (45L, 3C)

Rationale: *A good knowledge of metric spaces and a basic knowledge of topology is a must for*

those who want to do well in pure mathematics, applied mathematics or financial mathematics. This course provides this knowledge.

Prerequisites: *PM 3054*

Intended Learning Outcomes: *By the end of the course, students should be able to:*

- *Explain and use advanced concepts in metric spaces, and*
- *Explain and use basic concepts in topology.*

Course content:
Metric spaces: Convergence: Convergent sequences, Cauchy sequences, complete spaces, Cantor's intersection theorem, dense sets and separable spaces, nowhere dense sets, Baire's category theorem, sequences and continuity, extension theorems, isometries and completion of spaces. Compactness: Compactness of a space and the compact subsets of a space, theorems on compact subsets of a Space, theorems on compact subsets of the space R", compactness of the Cantor set; Equivalence of compactness, sequential compactness, and the Bolzano Weirstrass property; Compactness and the finite intersection property, continuity and compactness. Connectedness: Separated sets, disconnected and connected sets, connected subsets of R, continuous functions and connected sets. Topological spaces: Definition and examples, subspace topology, comparison of topologies; Definitions in topological spaces (boundary point, dense set, etc.); Bases and sub-bases; The product topology X x Y, order topology, lower limit topology and upper limit topology; Compactness and connectedness (definitions only), Continuity, homeomorphism, topological property; First countable and second countable spaces; Convergence in first countable spaces.

Method/ s of Evaluation: *End of semester examination (at least 70%) and Continuous assessment (at most 30%) and these two components add up to 100%.*

Suggested References:

- *Topology A First Course by James R. Munkres*
- *Principles of Mathematical Analysis by Walter Rudin*
- *Introduction to Topology Pure and Applied by Colin Adams and Robert Franzosa*
- *Introduction to Topology and Modern Analysis by George F. Simmons*

PM 3056: Real Analysis I 45L (2C)

Rationale: *This course focus on providing a rigorous foundation to real analysis.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to:

- *Define limsup, liminf and use it in the analysis of convergence of sequences and series.*
- *Solve problems in sequences and series, including the determination of convergence of a series and a powerseries using convergence tests.*

- *Define continuity, uniform continuity and analyze continuous functions on a compact (closed and bounded)set.*
- *Analyze the convergence properties of sequences of functions, including uniform and point wise convergence.*
- *Analyze the differentiability of a function and, use Rolle's theorem, mean value theorem and other related results.*
- *Describe calculus of functions of more than one variable, by means of limits, repeated limits, continuity, partial derivatives and differentiation.*

Course Content:

Syllabus: Sequences: Subsequences; Cluster point of a sequence; Limsup and liminf; Proof of Cauchy condition; Bolzano-weierstrass theorem. Series: d'Alembert's ratio test and Cauchy's root test in terms of limsup and liminf; Existence of radius of convergence of a power series.Sequences and series of functions: Pointwise convergence and uniform convergence of a sequence of functions; Weierstrass M' test and Dirichlet's test for uniform convergence of a sequence of functions. Functions: Boundedness of a function (continuous functions being bounded on a closed interval, continuous functions on a closed interval taking maximum and minimum values at points in the interval); Uniform continuity (functions being continuous on a closed interval); Rolle's theorem, mean value theorem, Taylor's theorem and Maclaurin's theorem (all these theorems with proof), l'Hospital's rule; Functions defined by series (exponential, logarithmic, trigonometric and hypobolic functions).Functions of several variables: Limits, repeated limits, continuity, partial derivatives and differentiation.

Method/s of Evaluation: *End of semester examination*

Suggested References:

- *Principles of Mathematical Analysis, Walter Rudin, 3rd Edition*
- *Mathematical Analysis, Tom M. Apostol, 2nd Edition*

AM 3002 Computer Applications in Discrete Mathematics (30L, 30P ; 3C)

Rationale: *This course unit is introduced to provide an introduction to Discrete mathematics.*

Prerequisites: *None*

A selected number of students will be chosen based on their total marks of the 1^{st} and 2^{nd} year Applied Mathematics core courses. In addition to this, any student following Mathematics Special or the joint special 'Mathematics, Statistics with Computer Science' will be eligible to follow this course.

Intended Learning Outcomes:

By the end of the course, students should be able to

- *solve basic problems in graph theory.*
- *solve applied graph theory problems using computer languages such as Java.*

- *explain how to find the time complexity of an algorithm.*

Course Content:

Most of the following languages and packages will be used in applying discrete mathematics - JAVA (only introductory material), Window packages; Connecting to databases using relevant packages. Any language or package can be replaced by another equivalent language or package. Advanced Topics: Complexity of algorithm; Introduction to graph theory; Huffman Codes; Encoding matrices; Decoding tables; Breadth first search and depth first search for spanning trees; Prim's algorithm and Kruskal's algorithm for minimum spanning trees; Shortest path algorithm; Euclidean algorithm; Sorting algorithms and sorting trees; Search algorithms; Complexity of algorithms; Analysis of algorithms; Infix, prefix and postfix forms; Binary strings; Traveling salesman problem; Algorithms with applications in Java, C++. Automata, grammars and languages; Finite-state machines; Finite state automate; Languages and grammars; Contest-free grammars and context-sensitive grammars; String fractals.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Graph Theory: An introductory course (Springer): Bela Bollobas*
- *Introduction to Graph Theory (Pearson): Douglas West*
- *Graph Algorithms and Ramsey Theory (Sarasavi): Jayawardene*

AM 3004: Mathematical Modelling in Economics and Business (45L, 3C)

Rationale: *This course unit is intended to give an overview of mathematical applications in economics.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of the course students are expected have a good knowledge of*

- *Basic micro and macro economic models*
- *Ability to analyse and extend the models they studied*

Course Content *:*

Introduction: Introduction to economics and business; Role of mathematics in economics and business; General study of demand, supply and market equilibrium. Economic models. Static and comparative-static analysis of market models, inventory models, input-output models and selected macro economic models, Effect of taxation on static market models; Dynamic analysis (in continuous and discrete time) of market models, inventory models, input-output models, financial models and some macro economic models, Effect of taxation on dynamic market models. Elasticity and other economic concepts: Elasticity of demand and supply; Point and cross elasticities; Analysis of single product and joint products cost, revenue, average cost, price, profit functions etc.; Marginal analysis, consumer's surplus and producer's surplus; Optimisation of revenue, cost and profit functions of single product and joint products. Consumer demand theory: Derivation of utility functions; Maximizing utility functions with and

without budget constraints; Derivation of demand functions; Indifference curves; Marginal rate of substitution and contract curves (Edgeworth box). Introduction to game theory: Zero-sum matrix games; Single and mixed strategy games; Optimal strategies; Dominance; Simple applications.

***Method/ s of Evaluation**: End of semester examination.*

Suggested References:

- *Fundamental Methods of Mathematical Economics by Alpha C Chiang. Third Edition McGraw HillInc.*
- *Introductory Mathematics for Economics and Business by K Holden and A W Pearson. Second Edition McMillan Press.*

AM 3005: Mathematical Methods (45L, 3C)

***Rationale:** This course provides an introduction to Systems of ordinary differential equations, Fourier series, Fourier transforms, Laplace transforms and Partial differential equations.*

***Prerequisites:** None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *find solutions, draw the phase diagram and comment on the stability of the solutions of a given system of ordinary differential equations.*
- *find the Fourier series of a given function and determine the convergence of the series.*
- *find the Fourier integral of a given function and determine the convergence of the integral.*
- *find the Fourier transform, inverse Fourier transform of a given function.*
- *find the Laplace transform, inverse Laplace transform of a given function.*
- *solve a given partial differential equation*

***Course Content:** Systems of ordinary differential equations, phase diagrams, stability of solutions, Fourier series, Fourier transforms, Laplace transforms and their applications, Partial differential equations: Laplace equation, Heat equation, wave equation, Finite difference approximation of partial differential equations,*

***Method/s of Evaluation:** End of semester examination*

***Suggested References:** Ordinary differential equations by W. Cox*

- *Differential equations by R.Bronson*
- *Elementary differential equation by E.D.Rainville*

- *Schaum's outline of Fourier analysis with applications to boundary value problems by M.Spiegel*
- *Schaum's outline of theory and problems of Laplace transforms by M.Spiegel*

AM 3006 Financial Mathematics (3C, 45L)

Rationale: *This course explores the theoretical aspects of finance and valuation of money and prices financial instruments.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *explain basics valuation method*
- *identify the impotency of time value concept*
- *value the different cash flows*
- *price the different financial instruments*
- *apply techniques to find the feasibility of real projects*

Course Content:

Introduction: Accumulation functions, present values, simple interest, compound interest, discounts, forces of interest and discount, interest rates in discrete and continuous time. Annuities: Elementary annuities -immediate and due, perpetuities, more general annuities, annuities payable less or more frequently than interest conversion, continuous annuities, payments varying in arithmetic/ geometric/ other patterns, continuously varying annuities. Amortization schedules and sinking funds: Outstanding principal, amortization schedules, sinking funds, schedules when payment periods and interest conversion periods coincide and when these periods are different, varying series of payments, yield rates, reinvestment rates. Bonds and other securities: Types of securities and bonds, price of a bond, premium and discount, valuation between interest payment dates, callable/ serial bonds, valuation of securities. Basic option theory: Introduction, Call option, put option, Asian option.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *Ross, SA, Westerfield, RW, J ordan, BD, (2002), Fundamentals of Corporate Finance, 8th edition, McGraw-Hill Publishing Company.*
- *Kellison, SG, (2008), The Theory on Interest, 6th Edition, Richard D. Irwin Inc.*
- *Per y H. Beaumont (2004), Financial Engineering Principles: A Unified Theory for Financial Product Analysis and Valuation, John Wiley & Sons, Inc.*

AM 3007 Computer Applications in Combinatorics (30L, 30P ; 3C)

Rationale: *This course unit is introduced to provide an introduction to counting.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *solve basic problems in combinatorics.*
- *solve counting problems using computer languages such as Java.*
- *explain how to find the time complexity of an algorithm.*

Course Content:

Problems related to counting; Problems related to cyclic order; Pigeonhole principle; Ordered and unordered selections; Counting problems related to partition functions; Algorithms in generating combinations and permutations; Generalized permutations and combinations; Introduction to VC++; Working with Timers; Menus, Toolbars; Status bars and Dialog boxes. Using Visual C++ (swing), creating a user interface to solve counting problems. Examples of permutations and combinations in applied probability; Applications of permutations and combinations using Visual C++ and other programming languages; Generalized multiplications; Binomial expansion, Binomial coefficients, Binomial expansion and its relation with combinations, Multinomial coefficients and multinomial expansions; Combinatorial identities; Creating a user interface using Visual C++ (swing) to verify combinatorial identities (for some special cases); Counting problems. Proofs to combinatorial identities using permutations and combinations; Problems related to combinatorial identities. VC++ may be replaced by another Object-Oriented Language.

Note: Any special students having to take AM 3002 as a compulsory course may opt to take AM 3007 instead. A student is not allowed to take this course if he or she is taking AM 3002.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Combinatorics (Cambridge press): Bela Bollobas*
- *A course in Combinatorics (Cambridge press): Lint and Wilson*
- *Theory and Problems of Combinatorics including concepts of Graph Theory (Schaum): Balakrishnan*
- *A First Course in Discrete Mathematics (Springer): Ian C. Anderson*
- *Discrete Mathematics with Applications in Counting (Sarasavi): Jayawardene*

AM 3008: Corporate Finance (30L, 30 P, 3C)

Rationale: *This course explores the theoretical aspects of finance and valuation of money, prices financial instruments/ projects and theories of corporate sector.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *explain and identify different valuation method*
- *identify the impotency of time value concept for valuing real projects*
- *value the cash flows related to investment projects*
- *price the different financial instruments/ projects*
- *apply techniques to find the feasibility of real projects*

Course Content:

Introduction: Corporate Structure, Capital Budgeting, Investment Opportunities (long-term/short-term) and appraisal. Accumulation functions, present values, simple interest, compound Interest, discounts, forces of interest and discount, interest rates in discrete and continuous time. Formal methods used in capital budgeting (Net Present Value, Payback Period, Internal Rate of Return), Financial Market principles and processes, transactions in various markets, using different models in predicting outcomes. Bonds and other Securities: Types of securities and bonds, price of a bond, premium and discount, valuation between interest payment dates, Valuation of securities, techniques determining intrinsic value of securities and bonds, Interaction between the Economy and the Financial Market.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *Ross, SA, Westerfield, RW, Jordan, BD, (2002), Fundamentals of Corporate Finance, 8th edition, McGraw-Hill Publishing Company.*
- *Marek Capinski &Tomasz Zastawniak (2003), Mathematics for Finance: An Introduction to Financial Engineering, Springer.*
- *Perry H. Beaumont (2004), Financial Engineering Principles: A Unified Theory for Financial Product Analysis and Valuation, John Wiley & Sons, Inc.*

AM 3009 - Mathematical Methods for Finance (3 Credits 30 L 30 P)

Rationale: *This course unit is introduced to provide a more realistic experience in financial sector in particular on application of the differential equations governing financial markets.*

Prerequisites: *None*

Expected learning outcomes:

By the end of the course, students should be able to

- *Relate differential equations to problems in finance and insurance*
- *Solve a system of ordinary differential equations*
- *Perform basic computations related to pricing theory using Excel*
- *Calculate option pricing using different models such as Black-Scholes*

Course Content:

Introduction: Differential Equations, systems of ordinary differential equations, phase diagrams, stability of solutions, applications of first order differential equations in Finance. Using Excel in Finance and Insurance. Introduction to Excel (using functions and macros, FV, PMT, NPER, RATE). Basic Option Theory: Introduction, Call Option, Put Option, Option Pricing. Using Excel in Option Pricing, Option Pricing spreadsheet using different methods (Black-Scholes, Monte Carlo, Binomial Trees).

Method/ s of Evaluation: *Final Examination 70% Practical and/ or Continuous Assessments 30%*

Suggested References:

- *Korn, R. and Korn, E., 2001. Option Pricing and Portfolio Optimization: Modern Methods of Financial Mathematics (Vol. 31). American Mathematical Society*
- *Achdou, Y. and Pironneau, O., 2005. Computational Methods for Option Pricing. SIAM*
- *Day, A., 2015. Mastering Financial Mathematics in Microsoft Excel: A practical guide to business calculations. Pearson*
- *Rouah, F.D. and Vainberg, G., 2007. Option Pricing Models and Volatility using Excel-VBA (Vol. 361). John Wiley & Sons.*

AM 3050: Mathematical Methods (45L, 3C)

Rationale: *This course unit is intended to give an overview of advanced mathematical methods used in many scientific disciplines.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of this course students are expected to have a good knowledge of*

- *elliptical integrals, Fourier analysis, Fourier and Laplace transforms and the applications,*
- *calculus of variation.*

Course Content*: Gamma and Beta functions; Elliptic integrals; Fourier analysis; PDE's; Solutions of linear PDE's with homogeneous and non-homogeneous boundary conditions; Variable separable methods; Fourier transforms, Laplace transforms; Fourier sine and cosine transforms; Calculus of variation;*

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Mathematical Methods in the physical sciences b y Mary L Boas — Second edition. John Wiley publication.*
- *Integral Transform and their applications by Lokenath Debnath, Dambaru Bhatta e-book.*
- *Introduction to partial differential equations by K Sankara Rao.*

AM 3051 : Numerical Analysis (45L, 3C)

Rationale: *Objectives of this course unit is to familiarize students with Numerical Methods of arriving at approximated solutions to systems of equations and differential equations, especially when direct methods are not applicable and estimating or predicting values related to a given data set through a fitted function using Numerical Methods.*

Prerequisites: *Prior knowledge of the topics covered in AM 2005*

Intended Learning Outcomes:

Upon successful completion, students will be able to;

- *Solve Systems of Equations using Numerical Methods*
- *Apply methods interpolation for predicting functional values*
- *Apply Numerical Methods for Solving Differential Equations*

Course Content:

Systems of linear equations: (a) Direct methods: Easy to solve systems; Forward and backward substitutions; Gaussian elimination; Pivoting strategies; Matrix factorization methods; Survey of software. Iterative methods: Norms of vectors and matrices; Basic concepts of iterative methods; Simple_1terat1ve methods, Jacobi method; Gauss-Scheidle method; Conjugate gradient method; SOR-methods; Convergence and error estimates; Survey of software. Cubic spline interpolation. Initial value problems for ordinary differential equations: Existence and uniqueness results; Linear multi-step methods; Consistency; Zero stability; Absolute stability and convergence; Survey of software. Boundary value problems for ordinary differential equations.

Method/ s of Evaluation: *End semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *Introduction to Numerical Analysis, 2nd edition, F. B. Hildebrand, ISBN-13: 978-0486653631 Dover Books.*

FM 3001 Mathematical Programming in Finance (30L, 30P, 3C)

Rationale: *The goal of this course is to formulate, analyse and solve several optimization models related to finance applications.*

Prerequisites: *None*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Develop a fundamental understanding of Integer and Dynamic programming models.*
- *Able to formulate Integer and Dynamic programming models from problem description.*
- *Able to solve Integer programming problems using Branch-and-Bound and Cutting-plane Algorithms.*
- *Able to solve Integer and Dynamic programming problems using Excel Solver and TORA programs.*

Course Content:

Formulating integer programming problems related to finance. Using Excel Solver and TORA programs to solve integer programming problems related to capital budgeting problem. Short term financial planning problem, Fixed charge problem, Risk insurance problem, Cutting stock problem, Problems related to cost curves, Traveling salesperson problem, Portfolio optimization problem. The branch and bound method. The implicit enumeration method using dual simplex algorithm. The cutting plane algorithm. Formulating and solving Dynamic programming problems related to finance. The Wagner Whitin algorithm. Forward recursion. Using spreadsheet to solve Dynamic programming problems in finance.

Method/s of Evaluation: *In class test, practical test and end of semester examination*

Suggested References:

- *H.A. Taha, Operational Research, 8^{th} / 10^{th} Editions 2009/2017, Pearson Prentice Hall.*
- *W.L. Winston, M. Venkataramanan, Introduction to Mathematical Programming, 4^{th} Edition 2003, Brooks/Cole, Cengage Learning*
- *3.F. S. Hillier and G. L. Lieberman, Introduction to Operations Research, 9^{th} Edition 2010, McGraw-Hill, New York.*

FM 3002 Actuarial Mathematics II (45L, 3C)

Rationale: *This course explores the advance theoretical aspects of random cash-flows particularly joint life insurance models and pricing of such models.*

Prerequisites: *FM 1001, FM 2002*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and concept of benefit reserves.*
- *evaluate the actuarial present value and net single premium.*
- *model and compute the premium.*
- *design and compute life insurance product.*
- *practice actuarial evaluation techniques.*

Course Content:

Net premiums: Continuous and discrete premiums, Apportionable premiums, Accumulation type benefits. Beneficial-Reserves: Continuous and discrete premium reserves, Reserves on an apportionable basis. Reserves at fractional durations, Allocation of the loss. Multiple life random variables: Joint and last survivor status, Probabilities and expectations, Annuity benefits, Special mortality laws, Contingent functions. Multiple decrement models: Random and deterministic survivorship group, Single and multiple decrement tables. Insurance models including expense Multi State Transition models: General expenses, Per policy expenses, Modified reserve methods.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *N L Bowers et al (1997), Actuarial mathematics, 2nd edition, Society of Actuaries.*
- *H U Gerber (1990), Life Insurance Mathematics, Springer.*

FM 3003 Calculus III (30L, 2C)

Rationale: *The goal of this course is to extend the previous knowledge of Calculus*

Prerequisites: *None*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Understand Vector Algebra, dot product, cross product and their applications*
- *Identify different forms of equations of Lines, Planes in three dimensional space*
- *Identify the equations of different surfaces*
- *Understand Polar, Cylindrical and Spherical Coordinates*
- *Understand differentiation and integration of Vector Valued Funtions*
- *Understand Arc Length*
- *Understand limit, partial derivatives of functions of two and three variables*
- *Determine equation of a tangent plane to a surface*
- *Understand directional derivatives to a surface*
- *Determine maxima, minima of real valued functions*
- *Apply Lagrange Multipliers to solve problems*

- *Understand applications of double and triple integrals*
- *Understand surface Integrals and the Divergence Theorem*
- *Understand Green's theorem and its applications*
- *Apply Stokes' theorem to simplify relevant problems*

Course Content:
Plane curves, Conics, parametric equations, polar coordinates and graphs. Vectors: Vectors in plane and space, Dot and Cross products, Lines, planes and surfaces in space, Cylindrical and Spherical coordinates, Vector valued functions: Differentiation and integration, Tangent and normal vectors, Arc length and curvature. Functions of several variables; Graphs of surfaces, Limits and continuity, Partial derivatives and differentiability, Linen approximation and error bounds, Chain rule, Directional derivatives and gradients, Tangent planes and normal lines, Extrema of functions of two variables and applications, Lagrange multipliers. Multiple integration: Iterated integrals, Double integrals and volumes, Change of variables and polar coordinates, Surface area, Triple integrals, Change of variables. Vector analysis: Vector fields, Line integrals, Conservative vector fields, Green's theorem, Surface integrals, Divergence theorem, Stoke's theorem.

Method/ s of Evaluation*; End of semester examination*

Suggested References:

- *Michael Corr al, Vector Calculus*
- *James Stewart, Calculus*

FM 3004 Numerical Methods for Finance (25L, 10P, 2C)

Rationale: *This course unit is introduced to provide an overview of useful mathematical methods for solving real-world problems.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Explain the stability of the solution of a linear system of equations*
- *Apply elimination and iterative methods to solve linear systems*
- *Interpret the convergence of a numerical method*
- *Solve ordinary differential equations using multi-step methods*
- *Obtain computational results for numerical solutions of linear systems and ordinary differential equations*

Course Content:

Understanding of advance topics in Numerical Methods. Linear multi-step method of solving ordinary differential equations, consistency, stability and convergence, Numerical methods of solving a linear system of equations, sparse systems, direct and iterative methods, convergence, Interpolation techniques of higher order accuracy.

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Meyer, C.D., 2000. Matrix Analysis and Applied Linear Algebra. SIAM*

FM 3006: Insurance Market and Products (3C, 30L, 30F)

Rationale: *This course unit is intended to give an overview of the operation of Insurance market and products.*

Prerequisites: *None*

Intended learning outcomes: *Upon the successful completion of the course the students should be able to understand and apply basic concepts of Insurance Market and Products.*

Course content: *Introduction to insurance market in domestic and international trade markets. Overview of market structures of Insurance. Understanding of the mechanics and terminology of various insurance based markets. Rating various risk coverages. Brokers role in Insurance market. Exposure to complexities of insurance marketing.*

Method/ s of evaluation: *End of semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *Fundamentals of the Insurance Business (Maggioni, Massimiliano, Turchetti, Giuseppe) 2018.*
- *Introduction to the Economics of Financial Markets (James Bradfield).*
- *Insurance and Behavioural Economics: Improving Decisions in the Most Misunderstood Industry (Howard C. Kunreuther, Mark V. Pauly, Stacey McMorrow) 2013.*

FM 3007: Financial Market and Products (3C, 30L, BOP)

Rationale: *This course unit is intended to give an overview of the operation of financial markets.*

Prerequisites*: None*

Intended learning outcomes: *Upon the successful completion of the course the students should be able to understand and apply basic concepts of Financial Market and Products.*

Course content:

Introduction to financial markets of both domestic and international institutions of the money and capital markets. Portfolio theory and management. Operation of financial intermediaries related to banks. Impact of bank regulations on the market and products. Exposure to complexities of a financial markets clue to accounting translations and loan associations.

Method/ s of evaluation: *End of semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *The Theory of investment Value (John Bur Williams).*
- *The Little Book of Behavioural investing (James Montier).*
- *Common Stocks and Uncommon Profits (Philip Fisher).*

MS 3001: Introduction to Game Theory (45L, 3C)

Rationale: *This course unit is introduced to offer a basic understanding of decision making under situations of conflict or competition.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Identify the prisoner's dilemma in real world situations*
- *Recall elementary games such as battle of sexes*
- *Solve two person-zero sum games using payoff polygons and simplex method*
- *Construct the extensive form of a game and convert to normal form*
- *Compute Nash equilibrium using best responses*
- *Explain the concept of Pareto optimality*
- *Describe models of duopoly and find equilibriua*

Course Content:

Introduction to: Static and Dynamic games with complete information. Static games with incomplete information, Payoff matrix, and applications. Static games with complete information: Standard games, zero-sum games, Prisoner's dilemma, battle of sexes, coordinate games, Chicken or Hark versus Dove. Basic Theory and Applications: Normal form games, Nash equilibrium, Iterated elimination of strictly dominated strategies. Cournot Model of Duopoly, Bertrand Model of Duopoly. Mixed strategies: Game theory applications in industry, politics. etc.

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Osborne, M.J ., 2004. An Introduction to Game Theory. New York: Oxford University Press.*

MS 3005 Introduction to Management Accounting (25L, l0P, 2C)

Rationale: *This course unit is introduced to provide an introduction and overview of basic Accounting theory and financial statements.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *identify basic principles accounts and balance sheet.*
- *identify the difference between various accounts.*
- *analysis of given balance sheet.*
- *apply theories prepare simple balance sheets.*

Course Content:

Accounting Theory and Financial Statements: Basic principles, Ledger accounting and Control accounts, Bank reconciliation, Intangibles, Suspense accounts, Trading, Profit and Loss accounts, Balance sheet, Trial balance, Income and Expenditure accounts, Incomplete records, Using Financial accounting packages. Cost Accounting Cost classification, Materials and Stocks control, Labour cost allocation and Overheads classification and analysis, Absorption and Marginal costing, Manufacturing and Departmental accounts, Budgets and budgetary control, Standard costing and variances, Integrated accounting systems and using Cost accounting packages.

Method/s of Evaluation: *End of semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *Peter Atrill, Eddie McLaney, David Harvey (2014), Accounting: An Introduction, 6th Edition, Pearson Australia.*
- *Peter Atrill, Eddie McLaney (2009), Management Accounting for Decision Makers, Financial Times/Prentice Hall*

MS 3008: Financial Accounting (3C, 45L)

Rationale: *This course unit is intended to give an overview of financial accounting concepts.*

Prerequisites: *None*

Intended learning outcomes;

Upon the successful completion of the course the students should be able to understand basic accounting concepts and use them for applications related to Financial Accounting.

Course content:

Introduction to Accounting. The Framework of financial statements. Accounting process. Recording transactions in the accounting equation. introduction to double entry. Prime entry books. Trail balance. Preparing basic financial statements from the trial balance. Accounting for returns, carriage and discounts. Accounting for accruals and prepayments. Accounting for irrecoverable debts and allowances for receivables. Accounting for inventory. Non-current asset acquisition, depreciation, revaluation and disposal. Accounting for errors. Control accounts and

bank reconciliation statement. The manufacturing account. Ratio analysis. Accounting Financial Reporting Standards.

Method/s of evaluation: *End of semester examination (70%) and Continuous assessment (30%)*

Suggested References:

- *Accounting Made simple (Mike Piper).*
- *Warren Buffett Accounting Book (Stig Brodersen, Preston Pysh).*
- *Accounting: The Ultimate Guide to Accounting for Beginners (Greg Shields).*

PM 4001: Commutative Algebra I and Category Theory (60L, 4C).

Rationale: *The goal of this course is to understand the algebraic structure Ring Theory with some examples and properties.*

Prerequisites: *Abstract Algebra*

Intended Learning Outcomes:

The students are expected to acquire the following skills in this course:

- *Understand the definition of the algebraic structure Ring and examples for Rings*
- *Understand zero divisors, Integral Domains and Sub rings*
- *Determine characteristic of a ring*
- *Understand Ideals*
- *Identify different types of ideals such as Principal, Maximal, Prime and Primary ideals*
- *Understand sum and product of ideals*
- *Identify Principal Ideal ring*
- *Understand ring homomorphism and properties*
- *Understand Correspondence Theorem, Isomorphism Theorems*
- *Understand Quotient ring, Factorization of Homomorphism and Fundamental homomorphism Theorem*
- *Identify the relationship between Integral Domains and Fields*
- *Construct quotient fields from Integral domains*
- *Understand divisibility theory in integral domains, greatest common divisor and least common multiplication*
- *Identify prime and irreducible elements*
- *Understand unique factorization domain, Principal Ideal Domain and relationship between them*
- *Understand Euclidean Domain*
- *Understand Polynomial rings*
- *Understand basic concepts of Category Theory and Functors.*

Course Content :

Ring Theory: Definition of a ring, examples and basic properties; Subrings; Ideals; Quotient

rings; Homomorphisms; Isomorphism theorems; Field of quotient of an integral domain; Prime, maximal and primary ideals; Divisibility theory; Euclidean rings; Polynomial rings.

***Method/ s of Evaluation**; End of semester examination*

Suggested References:

- *David M. Burton, A First Course in RINGS and IDEALS*
- *D.S.Malik, John M. Mordeson, M.K. Sen, Fundamentals of Abstract Algebra.*

PM 4002: Fields and Galois' Theory (60L, 4C)

***Rationale:** This course is introduced to provide techniques and analysis of some algebraic and geometric problems*

***Prerequisites:** Ring Theory (PM 4001)*

Intended Learning Outcomes:

- *Understand and solve problems concerning geometric constructability and solvability of algebraic equations,*
- *use Galois correspondence to understand other numerous problems while approaching to key algebraic problems,*
- *carry out individual research or literature survey projects.*

***Course Content:** Fields and Galois theory: algebraic and transcendental extensions; finitely generated and finite dimensional towers; algebraic numbers; Gaussian integers; quadratic integers; applications; rule and compass constructions; Galois groups of polynomials; Galois correspondence and applications, finite fields, insolvability. quintic equations; Fundamental theorem of algebra.*

***Method/ s of evaluation:** End of semester examination.*

Suggested References:

- *D.S. Dummit, R.M. Foote, Abstract Algebra, 3rd Edition.*
- *Galois Theory, Ian Stewart, ISBN 1-58488-393-6, 2004.*
- *Algebra, Thomas W. Hungerford, ISBN 0-387-90518-9, 2000.*

PM 4003: Measure Theory (60L, 4C)

***Rationale:** This Course unit is introduced to provide an introduction to fundamentals of Measure theory and Lebesgue integration*

Prerequisites:

***Intended Learning Outcomes:** At the end of this course, students should be able to*

- *Explain fundamental notions and results in Measure Theory and Lebesgue integration*
- *Understand the ideas behind the proofs of the major theorems such as Monotone convergence theorem, Fatou's lemma and Lebesgue dominated convergence theorem*
- *analyse examples and non-examples in Measure Theory and Lebesgue Integration*
- *apply the properties of Lebesgue measure and Lebesgue Integrals to make assertions about sets, functions and integrals*
- *formulate mathematical arguments in the context of Measure Theory and Lebesgue Integration*
- *construct examples and counterexamples in Measure Theory and Lebesgue Integration*

Course Content: *σ algebras of sets; Additive set functions and measures; Lebesgue outer measure; Measurable sets. and Lebesgue measure; Borel sets; Non-measurable sets; Measurable functions; Structure of measurable functions; Lebesgue integration; Fatou's lemma; Lebesgue monotone convergence theorem; Lebesgue dominated convergence theorem; Modes of convergence; Connection between Riemann and Lebesgue integrals. L^p spaces.*

Method/ s of evaluation: *End of semester examination*

Suggested References:

Real Analysis (Fourth Edition) by H. L. Royden and P. M. Fitzpatrick

Real Analysis; Modern Techniques and Their Applications (Second Edition) by Gerald B. Folland

Real Analysis; Measure Theory, Integration and Hilbert Spaces, Princeton lectures in Analysis III by Elias M. Steinand Rami Shakarchi

Lebesgue Integration on Euclidean Spaces, Revised edition, Frank Jones

PM 4004: Real Analysis (60L, 4C)

Rationale: *This course unit is introduced to provide an introduction to norms, normed linear spaces and integration of vector valued functions*

Prerequisites: *PM 3056 (Real Analysis I), PM 3052 (Real Analysis II)*

Intended Learning Outcomes:

By the end of the Course, students should be able to:

- *Define a norm and a normed linear space*
- *Define an inner product and an inner product space*
- *Prove or disprove that two norms are equivalent*
- *Define the norm convergence in function spaces*
- *Define the completeness of function spaces*
- *Determine the completeness of function spaces*

- *Define the absolute and non-absolute convergence of a series in a normed linear space*
- *Define the uniform convergence in a normed linear space and use the uniform convergence in the solutions of problems on normed linear spaces*
- *Prove the extension theorem for liner maps*
- *Define the integral of a vector valued step map and extend it to the regulated maps*
- *Analyze the properties of the integral of regulated maps*
- *Define the derivative of a regulated map*
- *Analyze the properties of integration and differentiation of regulated maps.*

Course Content:

Normed vector spaces: Definition, equivalent Norms, Norms that arise from inner products, Norms defined on R.

Sequence and functions spaces: Norm convergence of these spaces, Completeness, Limits in functions spaces, Continuous functions on compact sets, Equi-continuous families of functions, Completion of a Normed space.

Series: Non absolute convergence, Absolute convergence in Normed vector spaces,

Series of functions: Absolute and uniform convergence, Interchangeability of limits, Differentiability and Integrability of series of real functions.

Integration of vector valued functions: The extension theorem for linear maps, The integral of step maps and the extension of the integral to regulated maps, Properties of the integral, The derivative and relations between integration and differentiation, Interchanging derivatives and integrals (also involving improper integrals).

Method/ s of Evaluation: *End of semester examination*

Suggested References:

- *Serge Lang, Real and Functional Analysis, Third Edition*

PM 4005: Topological Spaces (60L, 4C)

Rationale: *This Course unit is introduced to provide an introduction to topological spaces with various properties*

Prerequisites : *None*

Intended Learning Outcomes: *At the end of this course, students should be able to*

- *Explain fundamental notions and results in the points set topology*
- *Understand the ideas behind the proofs of the major theorems such as Tychonoff Theorem, Urysohn lemma, Tietze extension theorem, separation theorems and*

metrization theorems

- *analyse examples and non-examples of topological spaces with various properties and continuous mapping between them*
- *apply the properties +of topological spaces to make assertions about topological spaces*
- *formulate mathematical arguments in the context of point set topology*
- *construct examples and counterexamples related to various properties of topological spaces*

Course Content:

Topological spaces: Continuous functions; Product topology)'; Metric topology; Connectedness; Components; Totally disconnected spaces; Locally connected space; Arcwise connected spaces; Compactness; Limit point compactness; Local compactness; Tychonoff theorem; Countability axioms; Separation axioms; Urysohn lemma; Tietze extension theorem; Urysohn metrization theorem.

Method/ s of evaluation: *End of semester examination.*

Suggested Reference:

- *James R. Munkres, Topology (Second Edition)*
- *James Dugundji, Topology*

PM 4006: Functional Analysis (60L, 4C)

Rationale*: This Course unit is introduced to provide an introduction to fundamentals of Banach and Hilbert space theory.*

Prerequisites: *None*

Intended Learning Outcomes: *At the end of this course, students should be able to*

- *Explain fundamental notions and results in Banach and Hilbert space theories*
- *Understand the ideas behind the proofs of the major theorems such as open mapping theorem, uniform boundedness and Hahn Banach theorem and Riesz representation theorem*
- *analyse examples and non-examples in Banach and Hilbert space theories*
- *apply the properties of Banach and Hilbert spaces, linear operators and linear functionals to make assertions about various normed spaces and linear operators between them.*
- *formulate mathematical arguments in the context of Banach and Hilbert space theories*

- *construct examples and counterexamples in Banach and Hilbert space theories*

Course Content:

Complete metric spaces: Contraction mapping theorem and Baire's category theorem. Normed linear spaces: Finite and infinite dimensional Spaces, convergence, completeness and compactness; Linear operators and bounded linear operators; Uniform boundedness theorem; Hahn Banach theorem ; Compact linear operators, linear functionals and bounded linear functionals; Generalized functions, dual Spaces, weak convergence; Spaces of bounded linear operators and bounded linear functionals; Convergence. Inner product spaces: Inner products and properties; Orthogonal complements, direct sums, orthogonal sets and sequences. Hilbert spaces: Properties, closest point theorem and applications; Bounded linear operators and bounded linear functionals on Hilbert spaces; Riesz representation theorem and Lax-Milligram theorem; Adjoint, self adjoint, unitary and normal operators. Applications: Differential equations, optimization, approximation theory, etc.

Method/s of evaluation: *End of semester examination.*

Suggested References:

- *Linear Functional Analysis, Second Edition by Bryan P. Rynne and Martin A. Youngson, Springer Undergraduate Mathematics series*
- *Functional Analysis, George Bachman and Lawrence Narici*
- *Introductory Functional Analysis with Applications, ErwinKreyszig*

PM 4007: Research Project (240P, 8C)

Rationale: *Research Project is based on lectures for undergraduate students, individual research assignments.*

Intended Research Project Outcomes:

- *Students should be able to present their individual original research work or literature survey projects,*
- *some of the projects can be continued for their further postgraduate studies.*

Prerequisites: PM 4001, PM 4002, PM 4005, PM 4006

Course Content: *There will be two assignments in Analysis and two assignments in Algebra. An assignment could be either a problem solving or a reading assignment. Problems will be assigned from the undergraduate material of the subject.*

Method/s of Evaluation*: Lecturer's evaluation - 20%, Presentation - 30%, Report - 50%*

Suggested References:

- *Relevant research publications.*

PM 4050 Complex Analysis (60L, 4C) - Same as PM 3053

PM 4051 Topology II (45L, 3C)* - *Same as PM 3055

AM 4001 Discrete Optimization with Computer Applications (60L, 4C)

Rationale: *This course unit is introduced to provide an introduction to Discrete Optimization.*

Prerequisites: *AM 1005 and AM 3002*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *solve problems in integer programming using computer languages such as Java and optimization packages such as LINGO/LINDO.*
- *solve problems in dynamic programming.*
- *solve problems in network programming.*
- *describe the differences between integer programming, dynamic programming and network programming.*

Course Content:

Integer and linear programming; Case studies with applications using the above packages. A variety of real life problems will be discussed. Assignment problems, transhipment problems, fixed-charged problems, machine/ work scheduling problems, inventory models, production process models, capital budgeting problems, financial planning problems, multi-period financial problems, network models, branch and bound method, cutting plane algorithm. implicit enumeration and maximum flow problems. Dynamic programming and genetic algorithms with applications. Applications in object-oriented programming languages such as C#. Languages: Most current computer languages will be introduced. Packages: Simulation packages to solve linear and non-linear optimization problems (e.g. Lindo, Lingo, SQL Spreadsheets)

Method/s of Evaluation: *End of semester examination.*

Suggested References:

- *Operations Research: An Introduction (Pearson), H. A. Taha*
- *Schaum's Outline of Operations Research (Schaum), Bronson and Naadimuthu*

AM 4002: Quantitative Methods (60L, 4C)

Rationale: *This course unit is intended to give an overview of mathematical applications in management and business.*

Prerequisites: *AM 3004*

Intended Learning outcomes: *On completion of the course students are expected to have a good knowledge of*

- *Basic business models*
- *Ability to analyse and extend the models they studied and do further research.*

Course Content:

Economic models: Static and dynamic analysis (in continuous and discrete time) of single and multimarket models; Equilibrium analysis existence, uniqueness and stability of equilibrium of models stated above.

Non-negative matrices and input-output models: Properties and some results on non-negative and M-matrices; Static and dynamic input-output models (open and closed ones); Input-output models as a linear-programming model.

Decision theory and utility theory: Decision making under uncertainty; Decision trees; Expected monetory value (EMV); Expected value of sample information (EVSI); Expected value of perfect information (EVPI); Problem with EMV; Utility theory utility axioms, consequences of sensible preferences (utility functions, theorems, implications and derivation of utilities), risk attitudes, Bayes' decision under a given utility.

Introduction to consumer demand theory and theory of production (A mathematical approach): Consumer theory, costs and perfectly competitive firms, monopoly and imperfect competition.

Game theory: Introduction to static and dynamic games with complete and incomplete information; Some economic. applications such as bargaining, auctions and bidding, job market signalling etc.

Stochastic matrices and Markov chains: Introduction and applications such as involving market shares, replacement policies, etc.

Other Applications: Some economic and business applications using linear and non-linear programming; Problems such as cutting stocks, resource allocation, equipment replacement, job assignments, portfolio analysis etc.

Method/ s of Evaluation:: *End of semester examination.*

Suggested References:

- *NonNegative Matrices in the Mathematical Sciences by A Berman and R J Plemmons. Academic Press.*
- *An Introduction to Management Science: quantitative approaches to decision making by D R Anderson, D J Sweeney and K Martin*

AM 4003: Actuarial Mathematics (60L, 4C)

Rationale: *This course explores the advance theoretical aspects of random cash-flows particularly life insurance models and pricing of such models and applications.*

Prerequisites: *AM 4005*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and concept of actuarial present value.*
- *understand differences between life insurance policies.*
- *evaluate the actuarial present value.*
- *practice actuarial evaluation techniques.*
- *evaluate the actuarial present value and net single premium.*
- *model and compute the premium.*
- *design and compute life insurance product.*

Course Content:

Survival distributions and life tables: The theory of survival models: Life expectancy, life insurance, discrete and continuous life insurance models. Life annuities: Introduction to annuity models, continuous whole life and the discrete life annuity due model. Net premiums: Fully discrete whole life, the aggregate determination and loss function approach, net premium reserves, multiple life functions, multiple decrement models, valuation theory for pension plans, insurance models including expenses, non-forfeiture benefits and dividends.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *N L Bowers et al (1997), Actuarial mathematics, 2nd edition, Society of Actuaries.*
- *H U Gerber (1990), Life Insurance Mathematics, Springer.*

AM 4004: Non-linear programming (60L, 4C)

Rationale: *Are all optimization problems linear? They are not. This course provides concepts and techniques for optimizing nonlinear functions.*

Prerequisites: *None*

Intended Learning Outcomes: *By the end of the course, students should be able to:*

- *Explain and use unconstrained optimization via calculus,*
- *Explain and use convex sets and convex function,*
- *Explain and use iterative methods for unconstrained optimization,*
- *Explain and use least squares optimization, and*
- *Explain and use convex programming and penalty methods.*

Course content:
Unconstrained optimization via calculus: The Hessian of a function; Positive and negative, semidefinite and definite matrices; Coercive functions and global minimizers; Iterative methods. Convex sets and convex functions: Convex sets in economics linear production models; Convexity and the arithmetic geometric mean inequality an introduction to geometric programming; Unconstrained geometric programming. Least squares optimization: Least squares fit; Subspaces and projections; Minimum norm solutions of undetermined linear systems; Generalized inner products and norms The portfolio problem. The Karush-Kuhn-Tucker conditions: Separation and support theorems for convex sets; Convex programming; The-Karush-Kuhn Tucker theorem; Dual convex programs; Penalty functions and the penalty method; Lagrange multipliers and the Karush -Kuhn Tucker theorem for mixed constraints; Quadratic programming.

Method/ s of Evaluation: *End of semester examination (at least 70%) and Continuous assessment (at most 30%) and these two components add up to 100%.*

Suggested References:

- *The Mathematics of Nonlinear Programming by A. L. Peressini, F. E. Sullivan, and J . J . Uhl,*

AM 4005: Theory of Interest and Corporate Finance (60L, 4C)

Rationale: *This course explores the theoretical aspects of finance and valuation of money, prices financial instruments/ projects and theories of corporate sector.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *explain and identify different valuation method*
- *identify the impotency of time value concept for valuing real projects*
- *value the cash flows related to investment projects*
- *price the different financial instruments*
- *apply techniques to find the feasibility of real projects*

Course Content:

Introduction: The purpose of this course is to introduce students to the mathematical applications in the financial industry (both actuarial and corporate finance). Part 1: Theory of interest: Accumulation/ amount function, discounting/ accumulating with compound interest, effective annual rate of discount with compound interest, equivalent rates of interest/ discount, nominal annual rates of interest/ discount, force of interest, cash flow terminology, cash flow valuation, principle of cash flow valuation, net present value, equivalent cash flows, basic annuity immediate/ due, basic deferred annuity, perpetuities, yield rates, capital budgeting,

amortization, sinking funds bond notation and terminology. Part 11: Corporate finance: Time value of money, valuations, risk and rates of return, capital budgeting, common stock, L T debt and preferred stock, working capital policies and S -T credit.

Method/ s of Evaluation:

End of semester examination (70%) and Continuous assessment (30%)

Suggested References:

- *Ross, SA, Westerfield, RW, J ordan, BD, (2002), Fundamentals of Corporate Finance, 8th edition, McGraw-Hill Publishing Company.*
- *Marek Capinski &Tomasz Zastawniak (2003), Mathematics for Finance: An Introduction to Financial Engineering, Springer.*
- *Per y H. Beaumont (2004), Financial Engineering Principles: A Unified Theory for Financial Product Analysis and Valuation, John Wiley & Sons, Inc.*

AM 4006: Partial Differential Equations and their Applications in Financial Derivatives (60L, 4C)

Rationale: *This course unit is introduced to provide an introduction to partial differential equations and their applications in option pricing.*

Prerequisites: *AM 1001, AM 2001, AM 2005, AM 3051*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *identify second order linear partial differential equations and classify them.*
- *solve parabolic partial differential equations using fundamental solution approach.*
- *find analytical solution of wide verity of initial boundary value problems.*
- *describe financial derivatives and their behavior.*
- *derive Black-Scholes formula and its equivalent forms as a solution of parabolic partial differential equation.*
- *price financial derivatives such as call and put options.*

Course Content:

Partial differential equations: Conservation laws, classifications, elementary analytical methods, initial/ boundary value problems. Diffusion equation: Fundamental solution, similarity solution, qualitative behaviour of diffusion initial value problems, Cauchy problem with infinite domain. Initial boundary value problems in the semi infinite domain, Green's function, homogeneous boundary value problems with inhomogeneous boundary condition. Hyperbolic equations: Characteristic methods, initial value problems with non-continuous initial data, introduction to weak solutions. Basic option theory: Call option, put option, Asian option, Black Sholes model and its derivatives. Numerical methods: Discretization of derivatives, boundary conditions, grids, finite difference methods for initial boundary value problems, consistency, stability,

convergence, applications of finite difference methods in financial derivatives.

Method/ s of Evaluation: *End of semester examination.*

Suggested References:

- *Partial Differential Equations: An by introduction by Walter A. Strauss*
- *Financial Derivatives by Paul Wilmot*
- *Options, Futures and other derivatives by John C Hull*

AM 4007: Research Project (180P, 6C)

Rationale: *This project is to see how the theories they have learned in the previous years could be applied to some real life problems.*

Prerequisites: *None*

Intended Learning outcomes: *On completion of the project students are expected have confidence in carrying out bigger research in mathematical applications.*

Course Content: *The student will do a research project typically on some mathematical and computational aspects of a real life problem arising from an industrial, financial or biological background and will write a dissertation on it. A part of the project could be carried out in collaboration with external bodies.*

Method/ s of Evaluation*: Lecturer's evaluation - 20%, Presentation - 30%, Report - 50%*

Suggested References:

- *Relevant research publications.*

AM 4008: Advanced Optimization (60L, 4C)

Rationale: *This course unit is intended to deep study of a few optimization topics.*

Prerequisites: *None*

Intended Learning outcomes:*On completion of the course students are expected have a good knowledge of*

- *inventory models, queuing and replacement models.*
- *Ability to analyse and extend these models and do further research.*

Course Content:

Inventory models: Introduction, reasons for holding inventories, cost of inventories, deterministic inventory models in continuous and discrete times. shortages, buffer stock,

instantaneous demand, continuous demand, price breaks. Stochastic inventory models.

Queuing models: Introduction, cost of queues, arrival and service time models, birth death processes, service in random order models, multi-channel models. '

Replacement models: Introduction, replacement of items that deteriorate, increase in maintenance and repair costs, change in value of money, item. Deterministic replacement models in continuous and discrete time, and stochastic replacement models.

***Method/ s of Evaluation**: End of semester examination.*

Suggested References:

- *Operations Research: methods and problems by M Sasieni, A Yaspan and L Friedman.*
- *Operations Research: An Introduction by Hamdy A Taha.*
- *Introduction to Probability Models by Sheldon M. Ross. Fifth Edition Academic Press.*

AM 4011: Research Project (180P, 6C)

***Rationale:** This project is to see how the theories they have learned in the previous years could be applied to some real life problems.*

***Prerequisites:** None*

***Intended Learning outcomes:** On completion of the project students are expected have confidence in carrying out bigger research in mathematical applications.*

***Course Content:** The student will do a research project typically on some mathematical and computational aspects of a real life problem arising from an industrial, financial or biological background and will write a dissertation on it. A part of the project could be carried out in collaboration with external bodies.*

***Method/ s of Evaluation**: Lecturer's evaluation - 20%, Presentation - 30%, Report -50%*

Suggested References:

- *Relevant research publications.*

AM 4012: Industrial Training (120P, 4C)

Rationale:

Virtually all mathematics special students become skilled at logical, analytical thinking and at formulating and modelling, and solving problems. But communication skills, teamwork and other soft skills are not always as highly developed in typical math programs. Often the best way to enhance these skills is to spend some time actually working in an industrial environment.

Prerequisites: None

Intended Learning outcomes:

The purpose of Industrial Training Program is to offer special degree students in Mathematical Finance, Finance, Business and Computational Mathematics and Mathematics & Statistics with Computer Science on opportunity to '

- *gain valuable real world work experience before their graduation*
- *experience concrete practical applications of principles learned in mathematics courses, and*
- *do their research projects in industrial working environment.*
- *The AM 4012 also provides an opportunity for employers to evaluate students as potential employees. The training and orientation invested in the students enhance their employability potential. Additionally, the program can foster closer interaction between the employers and the university.*

***Method/ s of Evaluation**:*

Each intern is required to submit a written report at the end of his/ her training. Evaluation of AM'4012 based on the written report (40%), presentation (50%) and the progress report (10%) by the industry supervisor.

***Suggested References:** ---*

AM4013: Case Study in Mathematical Modeling (90P, 3C)

***Rationale:** This course unit is introduced to practice theories of Mathematical Modeling and apply such theories in various fields.*

***Prerequisites:** None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and identify gap between theories and practical problems.*
- *apply existing theories to practical problems.*
- *modify theories and apply such modified theories to solve practical problems.*
- *prepare reports and conduct seminar on practical problem.*

Course Content:

Individual or group of students will be assigned Case Studies in Mathematical Modeling in various fields: Biology, Finance, Economics etc. of six month duration. A report submitted on the case study will be examined at a seminar presentation.

Method/ s of Evaluation:
Continuous assessment (Continues progress - 30%, Final presentation and viva – 30%, Report – 40%)

Suggested References:

- *B. Barnes, G..R. Fulford (2002), Mathematical Modelling with Case Studies: A Differential Equations Approach, 2nd Edition, CRC Press.*

FM 4001: Applied Functional Analysis (60L, 4C)

Rationale: *This course unit is introduced to offer both theoretical understanding and computational skills related to approximation methods in linear systems, optimisation and differential equations.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Define a Hilbertspace*
- *Compute best approximations for functions*
- *Compare least square solutions with other numerical approximations*
- *Interpret Fourier approximation in terms of function spaces*
- *Explain the stability of the solution of a linear system of equations*
- *Solve and analyse ordinary and partial differential equations*
- *Describe optimisation problems and solution methods using functionspaces*

Course Content:

Introduction to Normed Linear Spaces, Linear Transformations, Hilbert Spaces. Analysis of abstract equations: ODE, Stochastic differential equations, PDE. Spectral Theory and Applications. Applications: Stability Theory, Linear Systems Theory, Optimization problems, Numerical Methods.

Method/s of Evaluation*: End of semester examination.*

Suggested References:

- *Griffel, D.H., 2002. Applied Functional Analysis. Courier*
- *Balakrishnan, A.V., 2012. Applied Functional Analysis. Springer*
- *Hoffman, K. and Kunze, R., 1990. Linear Algebra. Prentice Hall*

FM 4002: FM Project (180P, 6C)

Rationale*: This course unit is introduced to practice theories and apply such theories in particular problem/ s.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and identify gap between theories and practical problems.*
- *apply existing theories to practical problems.*
- *modify theories and apply such modified theories to solve practical problems.*
- *prepare reports and conduct seminar on practical problem.*

Course Content:

Individual or group of students will be assigned a Mathematical Finance research project of one -year duration. A dissertation submitted on the project will be examined at a seminar presentation.

Method/ s of Evaluation:
Continuous assessment (Continues progress - 30%, Final presentation and viva – 30%, Report – 40%)

Suggested References:

- *Robert Bruner, Kenneth Eades, Michael Schill (2015), Case Studies in Finance, 7th Edition, Chegg Study.*

FM 4003: Case Studies in FM (90F, 3C)

Rationale: *This course unit is introduced to train and provide practical experiences in Finance sector.*

Prerequisites: *None*

Intended Learning Outcomes:

By the end of the course, students should be able to

- *understand and identify gap between theories and practical problems.*
- *apply existing theories to practical problems.*
- *compare techniques and modify such techniques.*
- *prepare executive summary and conduct seminar on practical problem.*

Course Content:

Individual or group of students will be assigned Case Studies in Mathematical Programming in

Finance, or Actuarial Mathematics, or Game Theory of six months duration. A report submitted on the case study will be examined at a seminar presentation.

Method/ s of Evaluation:

Continuous assessment (Continues Presentation - 30%, Final Seminar Viva – 30%, Report 40%)

Suggested References:

- *Robert Bruner, Kenneth Eades, Michael Schill (2015), Case Studies in Finance, 7th Edition, Chegg Study.*

FM 4004: Business Accounting (30L, 30P, 3C)

Rationale: *This course unit is intended to give an overview of financial and management accounting concepts.*

Prerequisites: *None*

Intended Learning outcomes: *Upon successful completion of the course the students should be able to understand basic accounting concepts and use them for applications related to Financial and Management Accounting.*

Course Content *: Introduction to Accounting theory, basic principles of Accounting, book keeping and accounting, Ledger Accounting and Control Accounts, Bank Reconciliation and Financial statements.*

Introduction to Management Accounting, Classification of costs, product costing, Budgets and budgetary controls, standard costing and variances.

Activity-based costing, activity drivers, cost drivers, contrast with traditional costing systems, Hierarchy of activities. Short run decisions, marginal costing, relevant costs, flexible budgets and special orders, Avoidable costs, product 'lines and outsourcing, Capacity costs and theory of constraints, uncertainty.

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Accounting Made simple (Mike Piper).*
- *Accounting Theory and Practice by M WE Glautierand B Underdown. Seventh Edition.*

FM4005: Microeconomics (30L, 2C)

Rationale: *This course unit is intended to give an overview of elementary microeconomic concepts.*

Prerequisites: None

Intended learning outcomes;

Upon the successful completion of the course the students should be able to understand basic

market mechanisms; perfect and imperfect competition, factor markets and interactions of markets.

Course content:

Introduction to Microeconomics: Introduction, Market and market mechanism. Market of Goods and Services: Consumer behaviour and formation of demand on market of goods and services, Firm behaviour and formation of supply on market of goods and services, Equilibrium on perfect competition market, Characteristics of imperfect competition, Firm behaviour in imperfect competition conditions, Profit as a stimulus and alternative goals of the firm.

Factor Markets: Formation of prices on factor markets, Labour market and wages, Capital market, Factormarket and splitting incomes.

Interaction of Markets: General equilibrium, Market failure and microeconomic state policy.

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Theory and Applications of Intermediate Microeconomics by W Nicholson and C Snyder.*
- *Essentials of Microeconomics by Krister Ahlersten*

FM 4006: Macroeconomics(3OL,2C)

Rationale: *This course unit is intended to give an overview of elementary macroeconomic concepts.*

Prerequisites: None

Intended learning outcomes;

Upon the successful completion of the course the students should be able to understand basic macroeconomic concepts ; aggregate demand and supply, money and asset market, business cycle.

Course content:

An overview of the Macroeconomy, The production function and aggregate supply,Foundation of aggregate demand, Open economy macroeconomics, Money and the role of asset markets, Theory of the business cycle, ISLM: A model of the macroeconomy, Classical business cycle theory, A Keynesian view of the world, The Philips curve: Unemployment and inflation, Exchange rates and the model in an open economy.

Method/ s of evaluation: *End of semester examination*

Suggested References:

- *Macroeconomics by N G Mankiw.*
- *Essentials of Macroeconomics by Peter J ochumzen*

FM 4007 - Economics II for Finance and Insurance – 3 C (45 L)

Rationale: *Objective of this course unit is to familiarize students with basic concepts, tools, and techniques relating to financial and insurance market. The course unit is built on the foundation of FM 3005 offered in 3rd year.*

Pre-requisite: *FM 3005*

Intended LearningOutcomes:

Upon successful completion, students will be able to;

- *Describe fundamental theories governing finance and insurance markets*
- *Apply basic tools in understanding financial and insurance products*
- *Analyze financial and insurance markets*

Course Content:

The time-value of money, Introduction to financial instruments, Risk and return, Portfolio theory, Capital allocation, Pricing models, such as the Capital Asset Pricing Model and Index Model, Market efficiency, Equity valuation, Bond pricing and the Term Structure of Interest Rates, Derivatives - Pricing and Use, Selected Concepts of Decision Theory, Optimal Insurance Contracts under Complete Information, Adverse Selection in Insurance Markets, Moral Hazard in Insurance Markets

Method/s of Evaluation: *End semester examination (70%) and Continuous assessment (30%)*

Suggested Reference:

- *Zvi Bodie, Alex Kane and Alan J . Marcus, Investments, 8th edition, ISBN: 0-07-338237-X, McGraw-Hill.*

IT 4001 E-Commerce (20L, 20P, 2C)

Rationale: *This course unit is introduced to provide principles and practices in e-commerce environment including a practical experience in designing an e-commerce site.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Describe types of e-commerce*
- *Apply e-commerce principles*
- *Design an e-commerce site*

Course Content:

E-commerce principles: Concepts and types of e-commerce, methods of e-commerce solutions, create business case for an e-business, functional requirement for the e-business E-commerce Infrastructure: Specify technical requirement for the e-business, Guiding principles behind design and strategy of the customer web interface, management of on-line content, understand the traditional and new communication approaches

Method/ s of Evaluation: *Continuous Assessments (50%), End of semesterexamination (50%)*

Suggested References:

- *Korper, S. and Ellis, J ., 2000. The E-commerce Book: Building the E-empire. Elsevier*

IT 4002 Data Mining (30L, 30P, 3C)

Rationale: *This course unit introduces concepts and techniques of data mining and data warehousing and applications of data mining.*

Prerequisites: None

Expected learning outcomes:

By the end of the course, students should be able to

- *Apply OLAP (Online analytical processing) in analytical queries*
- *Describe applications and recent trends of data mining*
- *Use pre-processing of data*

Course Content:

Data warehousing and OLAP technology for data mining, Data pre-processing, Data mining primitives, languages and systems, Descriptive data mining: characterization and comparison, Association analysis Classification and prediction, Cluster analysis, Mining complex types of data, Applications and trends in data mining.

Method/s of Evaluation: *Practical 50%, End of semester examination 50%*

Suggested References:

- *Han, J ., Pei, J . and Kamber, M., 2011. Data Mining: Concepts and Techniques. Elsevier*
- *Thuraisingham, B., 2014. Data mining: Technologies, Techniques, Tools, and Trends. CRC Press*