Institute of Science and Technology

Master of Arts/Master of Science

M.A./M.Sc. Mathematics

Curriculum

1999

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M.A./M.Sc. Mathematics

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Introduction :

A new course structure for Master's Degree program in Mathematics has become imperative in view of the recently introduced Three Years Bachelor's Degree Program. Availability of additional specialists in new areas and upgrading the quality of the prospective students have been the key factorsfor the introduction of various new courses and revision of some old ones.

Objectives:

The Master's Degree course in Mathematics has been designed with the objectives:

(i) to give the students the knowledge of the fundamentals as well as the advanced areas of higher mathematics according to the recent international trends in mathematics;

(ii) to produce skilled manpower in mathematics for teaching and for other relevant academic activities;

(iii) to enable the students to conduct research in the field of their specialization.

Eligibility for Admission

The candidates who have passed B.A./B.Sc. Degree with major in mathematics from Tribhuvan University or its equivalent degree from another university recognized by Tribhuvan University shall be considered eligible to apply for admission to M.Sc./M.A.Mathematics. A./B. Sc. Program of TU.

Admission Criteria:

An applicant seeking admission to M.Sc./M.A.Mathematics must appear in an Entrance Examination of two hours' duration conducted by the Central Department of Mathematics / Campus. The applicant who fails to obtain a minimum qualifying score will not be granted admission. A merit list of the qualified applicants will be prepared on the basis of the percentage of marks in their B.A./B. Sc. Examination and the marks obtained by them in the Entrance Examination. Admission of the students will be based strictly on the merit list and on the enrollment capacity of the Central Department of Mathematics / Campus.

Course Structure:

There will be altogether 10 courses, five in each academic year, and each course carries 100 marks. In each course the minimum number of periods per week is 6 (4 for theory classes and 2 for problem classes), and the duration of one period is of 1 hour.

First Year

Course No	Course Title	Full Marks	Pass Marks
Math 511	Topology	100	40
Math 512	Real Analysis	100	40
	Any ONE of the following		
Math 513	Complex Analysis and Differential Equations	100	40
Math 514	Theory of Functions	100	40
	Any TWO of the following		
Math 515	Algebra	100	40
Math 516	Differential Geometry	100	40
Math 517	Mechanics	100	40
Math 518	Nonlinear Programming and Scheduling I	100	40

Second Year

Any FIVE of the following:

Course No	Course Title	Full Marks	Pass Marks
Math 611	Measure Theory and Functional Analysis	100	40
Math 612	Integral transforms	100	40
Math 613	Distributions and Generalized Functions	100	40
Math 614	Commutative Algebra	100	40
Math 615	Algebraic Topology	100	40
Math 616	Algebraic Geometry	100	40
Math 617	Special Functions	100	40
Math 618	Univalent functions	100	40
Math 619	Partial differential Equations	100	40
Math 620	Dynamics of Viscous Fluids	100	40
Math 621	Relativity	100	40
Math 622	Nonlinear Programming and Scheduling II	100	40
Math 623	Numerical analysis	100	40
Math 624	Functions Spaces	100	40
Math 625	Geometry of Manifolds	100	40
Math 626	Thesis	100	40

Note: The taught courses (in both years) in a campus/department are determined at the discretion of the concerned head of the department. While selecting optional courses care should be taken that all the prerequisites and other requirements, as demanded by the syllabus of the course, are met.

Syllabi of Math 624 and Math 625 are to be prescribed later.

New optional courses may also be introduced, if approved by the Mathematics Subject Committee of TU.

Course Duration:

The duration of the program is of two academic years and there is a university examination at the end of each academic year.

Hours of Instruction:

a) Working days	:	150 days in an academic year
b) Class hour	:	
Theory	:	One theory paper of 100 marks will have 6 hours' lecture per week.
c) Attendance	:	70 percent attendance in the class is compulsory.

Examination:

The examination in each course (except Math 626) will be a written one carrying 100 marks and of 4 hours' duration. The question paper for the written examination in a course will consist of 10 questions, one from each unit, and each question will carry 10 marks; all questions are compulsory, and choices will be given from the same unit only in 4 questions.

Evaluation :

Institute of Science and Technology, Tribhuvan University will conduct annual examinations. The students will have to pass each level and each course numbers separately. The minimum pass marks is 40 percent.

A student who has passed his / her two years of study will be graded on the basis of the two years' average marks as follows:

75 percent and above	Distinction
60 percent and above	First Division
50 percent and above	Second Division
40 percent and above	Third Division

Topology
First Year

Course Title : Topology
Course No : Math 511
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: I

Course Description: The main aim of this course is to provide basic knowledge of point set topology. It also gives an introduction of homotopy theory and fundamental groups of topological spaces. The whole course is based on the text " Topology, a first course" by James R. Munkres. **The proofs of theorems with asterisk (*) will not be included in the final examination questions.** The solved examples and the exercise problems, which can be solved by the direct application of theorems and definitions, may form a part of the final examination questions.

Course Objectives:

- To provide basic knowledge of point set as well as algebraic topology in order to apply them in different branches of mathematics, and ;
- To lay the foundation for being able to continue further study in related fields.

Course Contents:

UNIT 1. *Definition and Basic Properties of Topological Spaces*: Review of sets, relations and functions, arbitrary Cartesian product, countable and uncountable sets, definitions and results of axiom of choice, maximum principle and well ordered sets, topological spaces, basis for a topology, the order topology, the product topology of XxY **15 hrs**

UNIT 2. *Continuous Functions and Other Topologies* : Subspace topology, closed sets and limit points, continuous functions, topology on arbitrary products. **12 hrs**

UNIT 3. *Metric and Quotient Topology*: Metric topology, metric topology continued, quotient topology. **12hrs**

UNIT 4. *Connectedness*: Connected spaces, connected sets in real line, components and path components. **14 hrs**

UNIT 5. *Compactness*: Compact spaces, compact sets in real line, limit point compactness, local compactness, * Tychonoff theorem. **16hrs**

UNIT 6. *Countability and Separation Axioms*: Countability axioms, separation axioms, *Urysohn lemma and * Tietze extension theorems, complete regular spaces. **14 hrs**

UNIT 7. *Paracompactness and Metrization Theorems*: Urysohn metrization theorem, local finiteness, * Negata- Smirnov theorem (necessary and sufficient), paracompactness, Smirnov metrization theorem. **16hrs**

UNIT 8. *Complete Metric Spaces and Function Spaces*: Complete metric space, compactness in metric spaces, pointwise and compact convergence, compact open topology, Baire spaces. **16hrs**

UNIT 9. *Homotopy of Path and Fundamental Groups*: Homotopy of paths, fundamental groups, covering spaces, fundamental group of a circle, fundamental group of punctured plane. **16hrs**

UNIT 10. *Further Fundamental groups and Homotopy Type*: Fundamental group of S^n, fundamental group of surfaces, essential and inessential maps, fundamental theorem of algebra, homotopy type. **16 hrs**

Text Books:

1. Munkres, J.R: Topology, a first course, Prentice Hall of India Pvt. Ltd., New Delhi, 1983.

Reference Books:

1. Dugundji J.: Topology, Allyn and Bacon, Boston, 1966.
2. Hocking J.G. and Young G.S.: Topology, Addison- Wesley Publishing Company, Inc, Reading , Mass, 1961.
3. Kelly J. L.: General Topology, Van Nostrand Reinhold Co, New York , 1955.
4. Massey W. S.: Algebraic Topology, An introduction, Harcourt Brace Jovanovich, New York, 1967.

Real Analysis

Course Title : Real Analysis
Course No : Math 512
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: I

Course Description: The course "Real Analysis" is a compulsory paper for the first year master level course in Mathematics. Some changes have been made in the subject matter as compared with the previous course: some topics have been omitted and some have been added. In the previous curriculum Measure theory and integration was very abstract and was not given due consideration on applications and problem-solving which was very essential for laying a strong foundation to the students in this field. In this draft we have tried to eliminate these defects and added some essential materials which help the students to build their understanding and research capacity in this field. This course is intended to provide a broader and deeper understanding of Lebesgue Integration and Functional Analysis. The overall aim of this course is to provide to the students not only the theoretical understanding but also to develop in them the capacity to solve problems and to initiate basic research works in this field.

Course objectives: After completion of this course the students will be able to;

- Define and use Lebesgue integration via Lebesgue measure,
- Prove some results concerning Lp space;
- Define various metric and Banach spaces of practical importance;
- Prove four fundamental theorems of functional analysis;
- Work on research in the field of functional analysis and Lebesgue integration;
- Apply the theorems on problem-solving in their fields;

Course Contents:

UNIT 1. *Elements of set theory*: Algebra of sets, axiom of choice, infinite direct products, partial orderings and the maximal principle, well ordering and the countable ordinals, Borel sets. **14 hrs.**

UNIT 2. *Lebesgue measure*: Introduction, outer measure,. measurable sets, Lebesgue measure, a nonmeasurable set, measurable functions, Littlewood's three principles. **16 hrs.**

UNIT 3. *The Lebesgue integral*: Riemann Integral, Lebesgue integral of a bounded function over a set of finite measure, integral of a nonnegative function, general Lebesgue integral, convergence in measure. **16 hrs.**

UNIT 4. *Differentiation and integration*: Differentiation of monotone functions, functions of bounded variation, differentiation of an integral, absolute continuity, convex functions. **12 hrs.**

UNIT 5. *Metric Space*: Definitions, inequalities of Holder and Minkowski for integrals, lp space, function spaces, convergence and related notions, separable space, complete space, completion, category, nowhere differentiable continuous functions, compactness, continuity. **16 hrs.**

UNIT 6. *Contractions, equicontinuity, semi-continuity and their applications* : Contractions and their applications to differential and integral equations, equicontinuity and its application to differential equations, Stone-Weierstrass theorems, normal families, semi-continuity, application to arc length, space of compact, convex sets. **16 hrs.**

UNIT 7. *Vector space*: Vector space, subspace, quotient space, dimension, Hamel basis, algebraic dual, second dual, convex sets, ordered groups, Hahn-Banach theorem (separation form), Hahn-Banach theorem (extension form), applications: Banach limits, invariant measure. **15 hrs.**

UNIT 8. *Banach Space*: Banach space, dual space, Hahn-Banach theorem in normed space, uniform boundedness principle with applications, lemma of F. Riesz and its applications, compact transformations, weak convergence, summability methods, approximate integration. **18 hrs.**

UNIT 9. *Second dual space, Open mapping and Closed graph theorems* : Second dual space, dual of lp, dual of C[a, b], Riesz representation theorem, open mapping and closed graph theorem, projections, Schauder expansion, operators in C[0, 1]. **15 hrs.**

UNIT 10. *Lp space* : The Lp space, completeness, approximation and smoothing operators, dual of Lp, p>1, dual of L1, Lp convergence of Fourier series. **12 hrs.**

Text Books;

1. Royden, H. L.: *Real Analysis (Third Edition)*, Prentice-Hall of India Private Limited, New Delhi.
2. Casper Goffman and George Pedrick,: *First Course in Functional Analysis*, Prentice-Hall of India Private Limited, New Delhi.

Reference Books:

1. Barra, de G.: *Measure and Integration*, Wiley Eastern Limited,New Delhi, India, 1991.
2. Sterling K. Barberian,: *Measure and Integration*, Chelsea Publishing Company, New York, 1970.
3. L. A Lusternik and V. J. Sobolev,: *Elements of Functional Analysis*, Hindustan Publishing Corporation, New Delhi, India, 1971.
4. Erwin Kreyszig,: *Introductory Functional Analysis with Applications*, John Wiley and Sons, New York, 1978.

Complex Analysis and Differential Equation

Course Title : Complex Analysis and Differential Equation — Full Marks : 100
Course No : Math 513 — Pass Marks: 40
Nature of the Course: Theory — Year: I

Course description : The course " complex analysis and differential equation" is a compulsory paper for the first year master's level in mathematics. This course is intended to provide a deeper and broader knowledge in this subject. The overall aim of this course is to provide theoretical knowledge to the students as well as to develop in them the capacity of problem-solving in their respective fields. To meet the aim the course has been divided into ten units consisting of analytic function, complex integration, series and sequences, residue theorem, conformal mapping and Riemann surfaces, analytical continuation, partial differential first and second order, existence and uniqueness theorems, series solution.

Course objective : The objective of the course is to provide the basic concepts of the topics in the theory of Complex variable and differential equations with a view to developing in the students a clear understanding of the theories in the subject so that after completion of this course they will be able to apply their knowledge in different fields of mathematics and mathematical sciences.

Course Contents:

Group A: COMPLEX ANALYSIS

UNIT 1. *Analytical functions and Complex integration*: Functions of complex variables, limits and continuity, derivatives, Cauchy-Riemann equations, analytic functions and some elementary functions, theory of analytic functions and some elementary functions, harmonic functions, contours and contour integrals, anti-derivatives and independence of path, Cauchy-Goursat theorem and its extension, Cauchy integral formula and extensions, Morera's Theorem, maximum moduli functions and maximum moduli principle, Liouville's theorem and fundamental theorem of algebra. **15 hrs.**

UNIT 2. *Series*: Convergence of sequence and series, Taylor series, Laurent series, further properties of series, absolute and uniform convergence of power series, uniqueness of series representation. **13 hrs.**

UNIT 3. *Residues and poles*: Singularities of functions and their different types, residue theorem, residue at poles, zeros and poles, evaluation of improper real integrals and definite integrals using calculus of residue, integration through a branch cut, meromorphic functions, number of zeros and poles logarithmic residue and Rouche's theorem and its applications **20 hrs.**

UNIT 4. *Mappings and conformal mappings*: Linear transformations, the transformation $w = 1/z$, bilinear transformations and their different cases, logarithmic and exponential transformations, $w = \sin z$, functions z^2 and $z^{1/2}$, successive transformations, conformal mappings, preservation of angles, further properties, harmonic conjugate, transformation by harmonic functions and boundary conditions. **15 hrs.**

UNIT 5. *Analytic continuation and Riemann surfaces*: Basic concept, condition under which f(z) = 0, analytic continuation and its uniqueness, principle of reflection, argument principle, Riemann surface for Logz, a surface for $z^{1/2}$ and surfaces for related finctions, Poison's integral formulas and Schwarz integral formula. **12 hrs.**

Group B : DIFFERENTIAL EQUATIONS

UNIT 6. *Existence and uniqueness*: General linear equations of first order, linear equation with constant coefficients, second order homogeneous equation, initial value problems for second order equations, basis of solutions, linearly dependent and independent solutions, Wronskian formula, homogeneous and non-homogeneous equations of order n, initial value problems for n-th order equations, theory of exact equations, method of successive approximations, Lipschitz condition, convergence of successive approximations and uniqueness of solutions. **15 hrs.**

UNIT 7. *Solution in series*: Ordinary and singular points, regular and irregular singular points, series solutions near regular singular points of indicial equation, power series solutions of (i) Legendre's equation, (ii) Bessel's equation (iii) Laguerre's equation, some properties of the special functions defined by the above equations. **15 hrs.**

UNIT 8. *Partial differential equations of the first order*: Pfaffian differential forms and equations, integration factor of Pfaffian differential equation, criterion for integrating factors, solution of Pfaffian differential equation in three variables, linear partial Differential equations of the first order, Lagrange's method of solving first order linear equations, integral surfaces and surfaces orthogonal to a given system of surfaces, non-linear partial differential equations, compatible systems, Charpit's and Jacobi's methods, special types, solutions satisfying given conditions. **15 hrs.**

UNIT 9. *Partial differential equations of the second order*: Classification of second order partial differential equations with constant coefficients into reducible and irreducible equations and with variable coefficients into three canonical forms, characteristic curves of the second order equations and characteristic equations in three variables, classification of equations in three independent variables, separation of variables, Non-Linear second order partial differential equations, Monge's method. **15 hrs.**

UNIT 10. *Applications of Partial Differential Equations*: Laplace's equations, wave and diffusion equations, their elementary solutions, method of separation of variables in different co-ordinate systems for solving these equations with special reference to boundary value problems. **15 hrs.**

Text Books:

1. Ruel V. Churchill and James Ward Brown ,: Complex Variables and Applications, McGraw-Hill International Edition.
2. Earl A. Coddington,: An Introduction to Ordinary Differential equations, Prentice-Hall of India.

3. George Simmons,: *Differential Equations with Applications and Historical Notes*, Tata Mc Graw - Hill Publishing Company Ltd., New Delhi.
4. Ian Sneddon,: *Elements of Partial Differential Equations*, McGraw-Hill Book Company.

Theory of Functions

Course Title : Theory of Functions
Course No : Math 514
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: I

Course Description : Although it is a classical subject, complex analysis is indispensable for almost all branches of mathematics. It is the progenitor of many modern areas of mathematics such as homotopy theory, manifolds, etc. This course is based on the book 'Functions of one Complex Variable' by J.B. Conway, which follows a modern approach to the subject.

Course Objectives:

Upon completion of this course the students will be able to

- acquire fundamental concepts in theory of analytic functions,
- apply the results of the subject in other areas of mathematics
- take up further study in advanced subjects like Univalent Functions

Course Contents:

Unit 1. *Some Elementary Concepts and Analytic Functions*: Lines and Half-Planes in the Complex Plane, Extended Plane and Spherical Representation, Distance between two Sets in a Metric Space, Uniform Convergence of Sequences and Series of Complex Valued Functions. Analytic Functions, Power Series, Exponential, Logarithmic and Trigonometric Series, Analytic Functions as Mappings, Linear Transformations. **20 hrs.**

Unit 2. *Complex Integration*: Riemann-Stieltjes Integrals, Power Series Representation of Analytic Functions, Zeros of an Analytic Function. **15 hrs.**

Unit 3. *Complex Integration continued* : Index of a Closed Curve, Cauchy's Theorem and Integral Formula, The Homotopic Version of Cauchy's Theorem and Simple Connectivity, Counting Zeros, Open Mapping Theorem, Goursat's Theorem. **15 hrs.**

Unit 4. *Singularities*: Classification of Singularities, Residue Theorem, Argument Principle. **15 hrs.**

Unit 5. *Maximum Modulus Theorem* : Maximum Principle, Schwarz Lemma, Convex Functions and Hadamard Three Circles Theorem, Phragman Lindelöf Theorem **13 hrs.**

Unit 6. *Convergence in Space of Analytic Functions*: Space of Continuous Functions, Spaces of Analytic Functions, Spaces of Meromorphic Functions. **15 hrs.**

Unit 7. *Convergence in Space of Analytic Functions continued*: Riemann Mapping Theorem, Weierstrass Factorisation Theorem, Factorisation of the Sine Function. **15 hrs.**

Unit 8. *Runge's Theorem*: Runge's Theorem, Simple Connectedness, Mittag-Lefler's Theorem. **12 hrs.**

Unit 9: *Analytic Continuation*: Schwarz Reflection Principle, Analytic Continuation along a Path, Monodromy Theorem. **10 hrs.**

Unit 10: *Harmonic and Entire Functions*: Basic Properties of Harmonic Functions, Harmonic Functions in a Disk, Jensen's Formula, the Genus and Order of an Entire Function, Hadamard Factorisation Theorem. **20 hrs.**

Text Book:

1. John B. Conway, *Functions of one Complex Variable, Second Edition*, Narosa Publishing House, New Delhi 1980.

Reference Books:

1. L.V. Ahlfors, *Complex Analysis, Third Edition*, McGraw-Hill Book Company 1979.
2. W. Rudin, *Real and Complex Analysis, Third Edition*, McGraw-Hill Book Company 1987.

Algebra

Course Title : Algebra
Course No : Math 515
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: I

Course Description: This course is designed for continuation of undergraduate level topics in three years' Bachelor program. In group theory, it covers free groups, structure of finitely generated abelian groups, sylow theory, solvable and Nilpotant groups basic concepts of rings, modules, free modules, are also included. It also includes Galois theory including Galois group of a polynomial.

Course objectives:
The main objectives of the course are:

- To impart further knowledge of group theory including free and finitely generated groups;
- To give understanding of fundamental results of group theory;
- To develop the concepts of Algebraic, Normal, Separable extensions;
- To impart the knowledge of Galois theory and its application;
- To give basic ideas of modules and their fundamental results.

Course Contents:
Unit 1. *Free group and finitely generated Abelian group.*: Review of basic concept of groups, Free groups, Free Abelian groups, Finitely generated Abelian groups, Krull-Schmidt theorem. **15 hrs.**
Unit 2. *Sylow theorems.*: Action of a group on a set, Sylow theorems, Applications of Sylow theorems, classification of finite groups. **15 hrs.**
Unit 3. *Solvable and Nilpotent groups.*: Normal and subnormal series, Jordan-Holder theorem, solvable groups, Nilpotent groups. **15 hrs.**
Unit 4. *Rings and Modules.*: Review of basic concepts of rings and ideals, rings of quotients and localization, ring of polynomials and formal power series, Modules, Submodules, fundamental concepts direct sums, quotient modules, homomorphism and exact sequences. **15 hrs.**
Unit 5. *Free Modules and Vector Spaces.*: Free modules and vector spaces, Bases, Dimension, Projective and Injective modules. **15 hrs.**
Unit 6. *Field extension and Galois theory.*: Field extension, Algebraic extensions, Galois theory, Fundamental theorems of Galois theory. 15 hrs.
Unit 7. *Splitting field.*: Splitting field, Algebraic closure and Normality, the Galois group of polynomials. **15 hrs.**
Unit 8. *Finite fields and further properties of field extension.*: Finite fields, Separability, cyclic extensions, cyclotomic extension, Radical extension.
15 hrs.

Unit 9. *Spectral theorem and Jordan form.*: Eigenvectors of symmetric linear maps, Spectral theorem, the complex case, unitary operators, Decomposition of vector-space with respect to an operator, Jordan normal form. **15 hrs.**

Unit 10 *Multi-linear products*: The tensor product, isomorphism of tensor products, alternating products special and general cases. **15 hrs.**

Text Books:

1. Hungerford, T.W.: *Algebra*, Springer verlang, 1981.
2. Lang, S.: *Liner Algebra* Addison-Wiley, 1982.

Reference Books:

1. P.B. Bhattacharya, S.K. Jain, S.R. Nogpaul,: *Basic Abstract Algebra*, Cambridge University Press. 1995.
2. Kenneth Hoffman and Ray Kunze,. *Linear Algebra* ,Prentice-Hall, 1992.
3. N.S. Gopal Krishnan,: *University Algebra*, Wiley, 1986.
4. M.J. McDonald,: *Group Theory*, New York, Harper and Row.
5. Marshall Hall,: *Group Theory*, New York, Macmillan.
6. P.M. Cohn.,: *Algebra vol. I (1985), vol. II(1989)* Wiley.
7. I.N Herstein,: *Topics in Algebra*., Wiley.
8. C.F. Gardiner,: *Algebraic Structures*, Ellis Horwood Limited, John Wesley & Sons, N.Y.
9. S. Lang,: *Algebra*, Addition Wesley, First ISE Reprint, 1999.

Differential Geometry

Course Title : Differential Geometry
Course No : Math 516
Nature of the Course: Theory

Full Marks : 100
Pass Mrks: 40
Year: I

Course Description: This course is designed to provide the students with an in-depth knowledge of Differential Geometry and Tensor Calculus. This course is divided into ten units. From unit one to unit seven the course contains topics on Theory of space curves , Geodesics and Fundamental equations of surface theory. From unit eight to unit ten, the course contains topics on Tensor algebra, Tensor calculus and Riemannian geometry.

Course Objectives:
The main objectives of this course are to enable the students:

- To acquires in-depth knowledge and a good theoretical background in differential geometry;
- To take up higher studies;
- To sustain interest in and to promote enjoyment of differential geometry and its application in various branches of mathematics and physical sciences.

Course Contents:

Unit 1. *The Theory of Space Curves*: Arc length, Tangent, normal and bi-normal, Curvature and torsion of a curve given as the intersection of two surfaces. **15 hrs**

Unit 2. The Theory of Space Curves (Contd): Contact between curves and surfaces, Tangent surface, involutes and evolutes, Intrinsic equations, fundamental existence theorem for space curves, Helices. **17 hrs,**

Unit 3. *Local Intrinsic Properties of a Surface*: Definition of a surface, Curves on a surface, Surfaces of revolution, Helicoids, Metric, Direction coefficients, Families of curves, Isometric correspondence, Intrinsic properties. **13 hrs,**

Unit 4. *Geodesics*: Geodesics, Canonical geodesic equations, Normal property of geodesics, Existence theorems, Geodesic parallels, Geodesic curvature, Gauss-Bonnet theorem, Gaussian curvature, Conformal mappings. **15 hrs.**

Unit 5. *Second Fundamental Form and Local Nonintrinsic Properties of a Surface*: The second fundamental form, Principal curvatures, Lines of curvature. **15 hrs.**

Unit 6. *Envelopes and Developables*: Developables, Developables associated with space curves, Developables associated with curves on surface, Minimal surfaces, Ruled surfaces. **15 hrs.**

Unit 7. *The Fundamental Equation of Surface Theory*: The fundamental equations of surface theory, Parallel surfaces, Fundamental exsistence theorem for surfaces. **15 hrs.**

Unit 8. *Tensor Algebra*: Vector spaces, The dual space, Tensor product of vector spaces, Transformation formulae, Contraction, Special tensors, Inner product, Associated tensors. **15 hrs.**

Unit 9. *Tensor Calculus*: Differentiable manifolds, Tangent vectors, Affine tensors and tensorial forms, Connexions, Covarient differentiation. **15 hrs.**

Unit 10. *Riemannian Geometry*: Riemannian manifolds, Metric, The fundamental theorem of local Riemannian geometry, Differential parameters, Curvature tensors, Geodesics. **15 hrs.**

Text Book :

1. P.J. Willmore : *An Introduction to Differential Geometry*, Oxford University Press.

Reference Book :

1. Weather Bern : *Differential Geometry* (ELBS)

Mechanics

Course Title : Mechanics
Course No : Math 517
Nature of the Course: Theory

Full Marks : 100
Pass Mrks: 40
Year: I

Course Description:-This course is designed to provide the students with an in-depth knowledge and theoretical background of Mechanics of a rigid body and Hydrodynamics and its spheres of application.

Course Objectives:-

The main objectives of this Courses are to enable the students:

- To develop sound in-depth knowledge of the emerging area of of Mechanics of a rigid body and hydrodynamics;
- To realize the importance of various aspects of Mechanics and Hydrodynamics and its application in everyday life;
- To take up further studies in higher Mechanics, fluid Mechanics and its various branches.

Course Contents:

Statics:

Unit 1. *Forces in Three dymensions.*: Systems of forces in three dimensions, Principle of vertual works in three dimesions,Pionsot's central axes and wrenches. **15 hrs.**

Unit 2. *Attraction and Potential.*: Attraction and Potentialof rod, disc, shperical shell, sphere. **15 hrs.**

Dynamics

Unit 3. *D'Alemberts's principle, motion in two dimensions.*: D'Alemberts's principle and equation of motion, motion in two dimensions under finite forces including sliding and rolling friction. **15 hrs.**

Unit 4. *Euler's equations*: Euler's equations of motion of a rigid body about itas fixed point and its application under no external forces. **15 hrs.**

Hydrodynamics.

Unit 5. *Kinemetics of fluid.*: Lagrangian and Eulerian methods, equation of continuity, boundary surfaces, stream lines and velocity potential. **15 hrs.**

Unit 6. *Equation of motion.* : Equation of motion for ideal fluid and their integrals. **15 hrs.**

Unit 7. *Motion in two dimentions* : Irrotational motion in two dimentions, source, sinks, and doublet and images in two dimensions **15 hrs.**

Unit 8. *Motion of cylinders.*: Irrotational motion of circular cylinders and elliptic cylinders in two dimensions. **15 hrs.**

Unit 9. *Motion in three dimensions.*: Motion of sphere, Stoke's stream function. **15 hrs.**

Unit 10. *Vortex motions.*: Vortex motion in two dimensions, Vortex Rows, Rectilinear Vortices with Circular Section. **15 hrs.**

Text Books:

1. Loney S. L. : *An Elementary Treatise on Statics*, Cambridge University Press.
2. Loney S. L. : *Elementary Treatise on Dynamics of a Particle and of Rigid Bodies*, Cambridge University Press.
3. Ramsey A. S. : *Dynamics Vol II* , Cambridge University Press.
4. Ramsey A. S. : *Hydro-dynamics*, (ELBS), G. Bell and Sons Ltd., London

Nonlinear programming and scheduling I

Course Title : Nonlinear programming and scheduling I — Full Marks : 100
Course No : Math 518 — Pass Marks: 40
Nature of the Course: Theory — Year: I

Course Description :This Course is about combinatorial optimization, scheduling modelling-algorithms and nonlinear programming. This course is designed to provide the students with an in depth knowledge of theoretical as well as practical background. The approach of the course will be mathematical modelling, methods and algorithms. The course relates with operations research, numerical mathematics, theoretical computer science and computing.

Course Objectives

The main objectives of this course are to enable the students:

- To broaden their mathematical knowledge towards mathematical models, methods and algorithms,
- To realize the importance of various aspects of optimization and its applications in everyday experience like industries, agriculture, etc.
- To be motivated and prepared for the study of more advanced field of optimization or scheduling.

Course Contents:

UNIT 1. *Network Flows and Efficient Algorithms*: Basic concepts of graphs and networks, the max-flow and min-cut theorem, the Ford and Fulkerson labeling, Dijkstra's algorithm, the Floyd-Warshall, the min-cost flow problem, algorithms (cycle, buildup and alphabeta), graph search, network labeling and diagraph search, max-flow algorithm. **15 hrs.**

UNIT 2. *Algorithms, Complexity and NP-Complete Problems*: Computability, time bounds, the size of an instance, analysis of algorithms, polynomial-time algorithms, np-complete problems introduction, an optimization problem as three problems, the classes p and np, polynomial- time reductions, Cook's theorem, clique, tsp, matching, covering, partitioning. **15 hrs.**

UNIT 3. *Integer Linear Programming (ILP) and Algorithms*: Introduction to ilp, total unimodularity, upper bounds for solution of ilp's, gomory cuts, lexicography, finiteness of the fractional dual algorithm, branch -and- bound for ilp and its general context with algorithm. **15 hrs.**

UNIT 4. *Mathematical Models and Methods of Scheduling*: Job data and characteristics, machine environment, optimilaty criteria, bipartite matching and assignment problems, arc coloring of bipartite graphs, introduction to shortest path problems and algorithms, the classes of scheduling, reductions between scheduling problems. **15 hrs.**

UNIT 5. *Single Machine Scheduling Problems*: Minimax criteria, maximum lateness and related criteria, total weighted completion time, idea of weighted number of late jobs and total weighted tardiness. **15 hrs.**

UNIT 6. *Parallel Machimes Scheduling Problems*: Independent jobs and identical machines, introduction to uniform machines and unrelated machines, jobs with precedence constraints. **15 hrs.**

UNIT 7. *Solutions, Algorithms and Basic Descent Methods*: Concepts of unconstrained optimization, first and second order conditions, convex programming, global convergence of descent algorithms, speed of convergence, Fibonacci and golden section search, line search by curve fitting, global convergence of curve fitting. **15 hrs.**

UNIT 8. *Descent and Conjugate Direction Methods*: Steepest descent and applications of the theory, Newton's method, coordinate descent, conjugate directions and descent properties, the conjugate gradient method and optimal process, the partial conjugate gradient. **15 hrs.**

UNIT 9. *Quasi-Newton Methods and Algorithms*: Modified Newton, construction of the inverse, Davidon-Fletcher-Powell, the Broyden family, convergence properties, memoryless quasi-Newton, combination of steepest descent and Newton. **15 hrs.**

UNIT 10. *Constrained Minimization Conditions*: Concepts and examples of constrained optimization, tangent plane, first and second order conditions, eigenvalues in tangent subspace, sensitivity analysis, inequality constraints. **15 hrs.**

Text Books:

1. C.H. Papadimitriou and K. Steiglitz: Combinatorial Optimizations; Prentice-Hall 1982.
2. Peter Brucker: Scheduling Algorithms; Springer Verlag, 1995.
3. David G. Luenberger: Linear and Nonlinear Programming; Addison-Wesley, 1984.

Reference Books:

1. G. Hadley: Nonlinear and Dynamic Programming; Addison-Wesley.
2. M.S. Bazaraa et al.: Nonlinear Programming Theory and Algorithms; John Wiley and Sons, N.Y.
3. Karl-Heinz Elster: Modern Mathematical Methods of Optimization; Springer Verlag, 1993.

Measure Theory and Functional Analysis

Course Title : Measure Theory and Functional Analysis
Course No : Math 611
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: II

Course Description: The course "Measure Theory and Functional Analysis" is the optional paper for the second year master level in Mathematics. This course is intended to provide a broader and deeper understanding of Measure Theory and Functional Analysis. The overall aim of this course is to provide to the students not only the theoretical understanding but also to enable them to initiate basic research works in this field.

Course objectives:

On completion of this course students will be able to:

- Understand general measure theory and integration;
- Get a fairly deep knowledge on Hilbert spaces and spectral theory;
- Work on research in the field of functional analysis and measure theory and integration; and
- Apply the theorems on problem-solving in their fields.

Course Contents:

UNIT 1. *Measure and integration*: Measure spaces, measurable functions, integration, general convergence theorems, signed measures, Radon-Nikodym theorem. **16 hrs.**

UNIT 2. *Measure and outer measure*: Outer measure and measurability, the extension theorem, Product measures, integral operators. **18 hrs.**

UNIT 3. *Inner product spaces, Hilbert spaces*: Inner product space Hilbert space, properties of inner product spaces, orthogonal complements and direct sums, orthogonal sets and sequences, series related to orthonormal sequences and sets, total orthonormal sets and sequences. **16 hrs.**

UNIT 4. *Linear operators and functionals*: Linear operators and functionals, representation of functionals on Hilbert spaces, Hilbert-adjoint operator, reflexive spaces. **14 hrs**

UNIT 5. *Strong and weak convergence*: Strong and weak convergence, convergence of sequences of operators and functionals, application to summability of sequences, numerical integration and weak* convergence. **14hrs.**

UNIT 6. *Spectral theory of linear operators*: Basic concepts in the spectral theory in normed spaces, spectral properties of bounded linear operators, properties of resolvent and spectrum. **14 hrs.**

UNIT 7. *Spectral theory of linear operators (continued)* : Use of complex analysis in spectral theory, Banach algebras and their properties. **13 hrs.**

UNIT 8. *Compact linear operators*: Compact linear operators on normed spaces and their properties, their spectral properties. **15hrs.**

UNIT 9. *Operator equations*: Operator equations involving compact linear operators, theorems of Fredholm type, Fredholm alternative. **15hrs.**

UNIT 10. *Spectral theorem for bounded self-adjoint operators*: Positive operators, the spectral decomposition, the operator calculus. **15 hrs.**

Text books:

1. H.L. Royden,: *Real Analysis (Third Edition),* Prentice-Hall of India Private Limited, New Delhi
2. Erwin Kreyszig,: *Introductory Functional Analysis with Applications*, John Wiley and Sons, New York, 1978.
3. Charles W. Groetsch,: *Elements of Applicable Functional Analysis*, Marcel Dekker,INC.,New York, 1980.

Reference books:

1. G.de Barra,: *Measure and Integration*, Wiley Eastern Limited, New Delhi, India, 1991.
2. Sterling K. Barberian,: *Measure and Integration,* Chelsea Publishing Company, New York, 1970.
3. L. A. Lusternik and V. J. Sobolev,: *Elements of Functional Analysis*, Hindustan Publishing Corporation, New Delhi, India, 1971.

Integral transform

Course Title : Integral transform | Full Marks : 100
Course No : Math 612 | Pass Marks: 40
Nature of the Course: Theory | Year: II

Course Title : Integral transform	Full Marks : 100
Course No : Math 612	Pass Marks: 40
Nature of the Course: Theory	Year: II

Course description: This course consists of ten units covering the course of introducing Fourier series, Fourier transforms and Laplace transforms. Besides this course, provides elementary concept an, generalized function and Schwarz distribution theory. Also some application of Laplace transform to solve the boundary value problems is set for study. Mellin transform, Stieltjes transform and other important transforms are introduced in this course.

Course objectives. This course of integral transform is designed to make the students get acquainted with the basic theory of Fourier series along with the important integral transforms and their applications in different branches of Mathematics and Physics. On completion of this course the students will understand the basic technique and theories of Integral transform and be able to conduct research in I.T. and generalized functions.

Course Contents:

Unit 1. *Fourier Series.*: Dirichlet's integrals. Riemann - Lebesgue lemmas convergency of Fourier Series, Different tests of convergency, Related theorems, Summability of Fourier Series, Fejer-Lebesgue theorem, Integration of Fourier Series Parseval's theorem and Riesz-Fischer theorem Riemann's first and second theorem, Schwarz's lemma, Uniqueness of Fourier Series.

18hrs.

Unit 2. *Fourier Transform.*: Introduction of integral transforms, Fourier Kernel, Fourier integral theorem. Fourier's transforms and properties, Continuity of Fourier transform, Fourier cosine transforms and sine transforms, Fourier transform of simple functions, Convolution theorem, Parseval's theorem for cosine and sine transforms, Applications and problems on Fourier transforms. **18 hrs.**

Unit 3. *Mellin Transform.*: Definition, Elementary properties, Mellin transforms of derivatives and integrals, Weyl fractional integral, Mellin inversion theorem, Convolution theorems and solution of integral equations

12 hrs.

Unit 4. *Hankel transform.*: Introduction, elementary properties of Hankel transform, Hankel inversion theorem with lemmas Hankel transforms of some elementary functions, Parseval theorem and Parseval relations for Hankel transforms, Relations between Fourier and Hankel transforms. **12 hrs.**

Unit 5. *Laplace Transform.*: Definition and elementary operational properties of L.T. Region of convergence of Laplace-Stieltjes transforms, Abscissa of convergence, Determination of abscissa of convergence, Absolute and uniform convergence , Analytic character of generating functions, Uniqueness of determining functions. **15hrs.**

Unit 6. *Complex inversion of L.T.*: The complex inversion formula, Summability of divergent integral, The convolution of functions, The Stieltjes resultant and the classical resultant, Order on vertical lines, Generating function analytic at infinity, Periodic determining functions **15 hrs.**

Unit 7: *Abelian and Tauberian theorem for Laplace transform.*: Stieltjes transform and its region of convergence, Tauberian theorems for the Stieltjes transform,, Hilbert transform and brilatesal Laplace transform, Iteration of Laplace transformations. **12 hrs.**

Unit 8: *Real inversion and Representation of Laplace transform.*: Post-Widder inversion formula, Laplace's asymptotic evaluation of an integral, Applications of the Laplace method, uniform convergence, the inversion operator for the Laplace-Lebesgue integral, the inversion operator for the Laplace-Stieltjes integral, the general representation theorem for the Laplace transform. **15hrs.**

Unit 9:*Application of Laplace transform.*: Laplace transform of some elementary function, Laplace transform of derivatives and integrals, use of Laplace transform to solve ordinary and partial differential equations with boundary value problems, Application of Laplace Transform to solve integral equations. **13hrs.**

Unit 10: *Introduction to Generalized function.*: Definition, the space of testing function, smooth functions, the Dirac delta functions, Schwarz's theory of distributions, Equality of distributions, theory of generalized functions, Definition, Ordinary functions generalized functions, Product of a distribution and a smooth function, the delta function, Fourier transform of distribution.

20hrs.

Text books:

1. D.V. Widder: *Laplace Transform*, Princeton University Press 1946
2. I.N. Snedden: *The use of Integral transforms*., Mc Graw-Hill Book Co.,N.Y. 1974
3. I.N. Snedden: *Fourier transforms*., Mc Graw-Hill Book Co.,N.Y. 1951
4. E.C Titchmarsh: *Theory of Functions*., Oxford University Press.

Reference Books.

1. T.M Apostle: *Mathematical Analysis*.,Narosa Publishing House, New Delhi.
2. A.H, Zemanian:*Theory of Generalized function and Integral transform*., Interscience Publication, N.Y.

Distributions and generalized functions

Course Title : Distributions and generalized functions. Full Marks : 100
Course No : Math 613 Pass Marks: 40
Nature of the Course: Theory Year: II

Course description: This course is intended to provide a deeper and broader knowledge in this field. To meet this objective, it has been divided into ten units consisting of distributions, calculation of distributions and its properties, distribution of slow growth, convolution of distribution, convolution equations. Fourier transformation,Laplace transformation and generalised functions. Each unit is given equal importance from the examination point of view. This course will be given with Math 612 integral transform.

Course objectives: The objective of the course is to provide basic concepts of the distributions and Generalized Functions so that after completion of the course the students will be able to apply their knowledge in different branches of mathematics and mathematical sciences.

Course Contents:

Unit 1. *Distributions and basic properties*: Testing functions and testing functions spaces, distributions and distributions spaces, Pseudo-functions, Hadamard's finite part of divergent integrals and Cauchy's principle value, testing functions and distributions of several variables equality of distributions, operations on distributions and distribution as local phenomena. **20 hrs.**

Unit 2: *Calculus of Distributions*: Convergence of distributions and some special cases, differentiation of distribution, primitives of distributions continuity and differentiability, distributions that depend upon parameter and integration with respect to that parameter. **10 hrs.**

Unit 3: *Some further properties of Distributions*: Characterization of delta functional and its derivatives, local bounded property of distributions, locally every distribution is a finite- order derivative of a continuous function. **10 hrs.**

Unit 4: *Distributions of slow growth*: Testing functions of rapid descent, distributions of slow growth, boundedness property for distributions of slow growth and differentiability property for application in $\delta\text{'t}$ to testing functions in $\delta t, T$ **10 hrs.**

Unit 5: *Convolution of distribution*: Direct product of distribution, support of distributions , commutativity and associativity of distributions, convolution of distributions and some operations, continuity of convolution process, convolution of a distribution in δ' with a testing function in δ and convolution operator. **15hrs.**

Unit 6: *Convolution equations*: Introduction, convolution Algebra, application to ordinary linear differential equations with constant coefficients and Minkowski's operational calculus. **10 hrs.**

Unit 7: *Fourier Transformation*: Ordinary Fourier transformation and its extension to distribution, Fourier transform of testing functions of rapid descent and Fourier transform of distribution of slow growth, Fourier transform of convolution of distributions having bounded supports Ultra-distributions, Fourier transform of arbitrary distributions and Fourier transform of convolution of distributions one of which has bounded support. **20 hrs.**

Unit 8: *Laplace Transformation*: Laplace transform of right-sided function, Laplace transform of right-sided distributions and its inversion, Laplace transform of convolution of right-sided distributions, Abelian theorems of initial and final types, Laplace transform of left-sided distributions and Laplace transform of distributions of unbounded supports and the use of Laplace transform in solving convolution equations, differential equations and integrodifferential equations with constant coefficients. **25 hrs.**

Unit 9. *Countably multinormed and countable-union spaces and their duals*: sequential-convergence spaces, semi-norms and multi-norms, countable-union spaces, duals of countably multi-normed spaces and duals of countable-union spaces, operators and adjoint operators. **15hrs.**

Unit 10: *Generalized functions*: The spaces $D_k(I)$, D(I) and their duals , the space ε (I) and its duals, generalized functions, two-sided Laplace transform of generalized functions, inversion and characterization of laplace transform of generalized functions. **15hrs.**

Text books:

1. Zemanian, A.H.: <u>*Distribution theory and transform analysis*</u>, McGraw Hill Book company, NewYork
2. Zemanian,A.H.: <u>*Generalized integral transformations*</u>, Inter-Science Publishers, New York, London.

Reference books.

1. Gel'fan, I.M., G.E. Shilov: <u>*Generalized functions Vol. I and Vol. II,*</u> Academic Press Inc., New York.
2. Helperin, I. : <u>*Introduction to the theory of distribution*</u>, Toronto University, Toronto, Canada.
3. Erdelyi , A. : <u>*Operational calculus and generalized functions*</u>, Holt Riehart and Winston, Inc., New York

Commutative Algebra

Course Title : Commutative Algebra. Full Marks : 100
Course No : Math 614 Pass Marks: 40
Nature of the Course: Theory Year: II

Course Description: The proposed course is designed to cover the main topics of Commutative Algebra. This course consists of fundamental concepts of commutative algebra, which includes important topics such as primary decomposition of ideals, localization, Dedekind domain, etc.

Course Objectives:

The main objectives of the proposed course are to enable the students;

- To get acquainted with fundamental concepts, terminologies of commutative algebra;
- To acquire the basic ideas, techniques and methods of commutative algebra; and
- To have an understanding of fundamental results of commutative rings and modules.

Course Contents:

Unit 1: *Rings and Ideals*: Prime ideals, Maximal ideals, Nil Radicals and Jacobson radical, operations on ideals, Extension and Contraction. **15 hrs.**

Unit 2. *Modules*: Finitely generated modules, Nakayama's lemma, Exact sequences, tensor product, Algebras and tensor product of algebras. **15 hrs.**

Unit 3.*Rings Modules of Fractions*: Local properties, Extended and contracted and ideals in rings of fractions. **15 hrs.**

Unit 4. *Primary decomposition*: Primary ideals, primary decomposition of an ideal, primary ideals under localization. **15 hrs.**

Unit 5. *Integral dependence and Valuation*: Integral dependence, the going up theorem, Integrally closed integral domain, the going down theorem, Valuation rings. **15 hrs.**

Unit 6. *Chain conditions*: Ascending and Descending chains, Noetherian and Artinian rings and their properties, Hilbert's basic theorem, primary decomposition in Noetherian. **15 hrs.**

Unit 7. *Noetherian and Artinian rings*: primary decomposition in Noetherian ring, further properties of Artinian rings, Structure theorem for Artinian rings. **15 hrs.**

Unit 8. *Discrete valuation rings and Dedekind domains*: Discrete valuation rings, Dedekind's domain and fractional ideals. **15 hrs.**

Unit 9. *Completion*: Topological and completions, Filpations, graded rings modules, the associated graded rings . **15 hrs.**

Unit 10. *Dimension theory*: Hilbert functions, dimension theory of Neotherian local rings Regular local rings, transcendental dimension. **15 hrs.**

Text Book:

1. M. F. Atiyah and I.G. Macdonald : *Introduction to commutative algebra*, Addison-Wesley Publishing company (1969)

Reference Books:

1. Miles Reid : *Undergraduate commutative Algebra*, London Mathematical Society, Student text, Cambridge University Press(1995)
2. Jacob Barshay : *Topics in ring theory*, W.A. Benjamin, Inc,(1969)
3. D.C. Northcott : *Ideal theory*, Cambridge University Press(1968)
4. Nathan Jacobson : *Basic Algebra Vol. 2,* Hindustan Publishing Corporation(India)
5. Oscar Zariski and Pierre Samuel : *Commutative Algebra Vol. I. and Vol. II*. Affiliated East-West Press Pt. Ltd. New Delhi. (1958)

Algebraic Topology

Course Title : Algebraic Topology
Course No : Math 615
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: II

Course Description: The main aim of this course is to provide sufficient knowledge of algebraic topology. The whole course is mainly based on the text "Elements of Algebraic Topology" by James R Munkres. The solved examples and the exercise problems, which can be solved by direct applications of theorems and definitions, may form a part of the final examination questions.

Course Objectives:

After completion of this course the students will be able to:

- understand the definitions of geometric simplexes and geometric complexes and their role in homology theory;
- define the simplicial and singular Homology Groups of different dimensions of topological Spaces;
- realize the role of homotopy in homology theory;
- generalize the concept of homotopy to define the higher homotopy groups of topological spaces;
- gain the sufficient knowledge of Algebraic topology in order to apply them in different branches of mathematics; and
- continue further study in the field of algebraic topology.

Course Contents:

Unit 1. *Homology Groups of a Simplicial Complex*: Simplexes, simplicial complexes and simplicial maps, abstract simplicial complexes, review of abelian groups, homology groups. **15 hrs.**

Unit 2. *Homology Groups And Induced Homomorphisms*: Homology groups of surfaces, zero dimensional homology, relative homology, homomorphisms, induced by simplicial maps, chain complexes and acyclic carriers. **15 hrs.**

Unit 3. *Simplicial Approximation*: Simplicial approximation, barycentric subdivision, the simplicial approximation theorem, algebra of subdivision. **15 hrs.**

Unit 4. *Homology Groups and Topological Invariance*: Topological invariance of homology groups, homomorphism induced by homotopic maps, maps of spheres, the Lefschetz fixed point theorem. **15 hrs.**

Unit 5. *Relative Homology*: The Exact Homology Sequence, The Zig- Zag Lemma, Mayer- Vietoris Sequenc, Categories And Functors **15 hrs.**

Unit 6. *Singular Homology Theory*: The singular homology theory, the axioms for singular theory, excision in singular homology, Mayer – Vietiris sequencs. **18 hrs.**

Unit 7. *Cohomology*: The Hom functor, simplicial cohomology groups, relative cohomology, cohomology theory **15 hrs.**

Unit 8. *Homology With Arbitrary Coefficients*: Tensor product, homology with arbitrary coefficients. **12 hrs.**

Unit 9. *Homological Algebra*: The exact functor, the universal coefficients theorem for cohomology, torsion product, the universal theorem for homology.
16 hrs.

Unit 10. *Higher Homotopy Groups*: Equivalent definition of π_n (X,xo), basic properties and examples, homotopy equivalence, homotopy groups of spheres, relation between (K) and π_n (|K|). **14 hrs**

Text Books:

1. James R. Munkres : *Elements of Algebraic Topology*, Addision – Wesley Publishing Company, Inc.
2. Fred H. Croom : *Basic Concept of Algebraic Topology*, Springer- Verlag

Reference Books:

1. Joseph J. Rotman : *An Introduction to Algebraic Topology*., Springer Verlag
2. Edwin H. Spanier : *Algebraic Topology*, McGraw –Hill Book Company
3. Massey Harcourt Brace Jovanovich : *Algebraic Topology, An Introduction*, New-York
4. J.W. Vick : *Homology Theory : An Introduction to Algebraic Topology* , Springer- Verlag

Algebraic Geometry

Course Title : Algebraic Geometry
Course No : Math 616
Nature of the Course: Theory

Full Marks : 100
Pass MNarks: 40
Year: II

Course Description: "This course is an elementary introduction to Algebraic Geometry . The main text book of this course is Algebraic Curves: by William Fulton. For the last unit " Algebraic Geometry" by R. Hartshorne may be used. The examples and the exercise problems, which can be solved by direct applications of the theorems and definitions, may appear in the final examination.

Course objectives:

After completion of this course, the students will be able to:

- define algebraic sets in both affine and projective n- spaces as the solution of a family of polynomials;
- possess sufficient examples of algebraic varieties (curves, surfaces, etc) in understanding various geometric properties;
- recognize and appreciate the linkage between the techniques of commutative algebra and geometric properties of varieties; and
- acquire basic knowledge for further study of and research in Algebraic Geometry, which is an important field of current research in Mathematics.

Course Contents:

Unit 1. *Affine Algebraic Sets*: Algebraic Preliminaries. Affine space and Algebraic sets, The ideal of a set of points, The Hilbert basis theorem , Irreducible components of an Algebraic set, Algebraic subsets of the plane, Hilbert's Nullstellensatz. **15 hrs**

Unit 2. *Some Topics on Commutative Algebra*: Modules and finiteness conditions, Integral elements. Field extensions, Direct product of Rings,. Operations with ideals, Ideals with finite number of zeros, Quotient modules and exact sequences, Free modules. **15 hrs**

Unit 3. *Affine Varieties*: Coordinate Rings, Polynomials maps, Coordinate changes, Rational functions and local rings, Discrete valuation rings, Forms. **15 hrs**

Unit 4. *Local properties of Plane Curves*: Multiple points and tangent lines, Multiplicities and local rings, Intersection numbers. **15 hrs**

Unit 5. *Projective Varieties*: Projective space, Projective Algebraic sets, Affine and Projective varieties. **15 hrs**

Unit 6. *Projective Plane Curves*: Basic definitions, Linear system of curves, Bezout's theorem, Multiple points, Max Noerthe's fundamental theorem, applications. **15 hrs**

Unit 7. *Varieties, Morphisms and Rational Maps*: The Zariski topology, Varieties, Morphisms of Varieties, Products and Graphs, Algebraic Function Fields and dimention of varieties, Rational maps. **15 hrs**

Unit 8. *Resolution of Singularities*: Rational maps of curves, Blowing up a point in A^2, Blowing up points in P^2, Quadratic tansformations, Non –singular modules of curves. **15 hrs**

Unit 9. *Riemann – Roch Theorem*: Divisors, Vector space L (D), Riemann's theorem, derivations and differentials, Canonical divisors, Riemann- Roch theorem. **15 hrs**

Unit 10. *Introduction to sheaves and schemes*: Sheaves, Schemes, First properties of schemes, Separated and proper Morphisms, Sheaves of Modules. **15 hrs**

Text Books:

1. William Fulton : Algebraic Curves, (An introduction to Algebraic Geometry), W.A. Benjamin Inc.
2. R. Hartshorne :Algebraic Geometry, Springer Verlag.

Reference Books:

1. R.J. Walker: Algebraic Curves, Springer Verlag.
2. Shafarevich I.R: Basic Algebraic Geometry, Springer- Verlag.
3. J. Harris: Algebraic Geometry, Springer- Verlag.
4. M. Atiyah, I.Mc Donald: Introduction to Algebraic Geometry, Addison Wesley.

Special Functions

Course Title : Special Functions — Full Marks : 100
Course No : Math 617 — Pass Marks: 40
Nature of the Course: Theory — Year: II

Course Description: Special Functions are usually studied and investigated by analytic methods. This course is designed to provide a comprehensive introduction to the various well-known Special Functions .

Course objectives:

The main objectives of this course are:

- to provide the basic knowledge and understanding of Gamma, Beta, Hypergeometric Functions, Confluent hypergeometric Functions and Bessel' s functions;
- to introduce some well-known orthogonal polynomials such as Hermite, Legendre and Laguerre polynomials; and
- to develop among the students skill in analytical techiques of studying special functions.

Course Contents:

Unit 1. *The Gamma and Beta functions*: Gamma functions, Euler's product, Integral representation, Difference equation, Factorial functions, Legendre's duplication formula, Beta function, Various properties and relations , Asymptotic series and its algebraic properties. **15 hrs**

Unit 2. *Hypergeometric Functions*: Hypergeometric function, Integral representation, Contiguous function relations, Differential equation, Elementary series manipulation, Transformations and properties. **15 hrs**

Unit 3. *Generalized Hypergeometic Functions and confluent Hypergeometric Function*: Generalized Hypergeometic Functions, Contiguous Function relations, Confluent Hypergeometric Function relations of Confluent Hypergeometric Functions, Kummer's first and second formulae. **15 hrs**

Unit 4.*Bessel function*: Bessel function, Recurrence relations, Generating functions Bessel's integral, Modified Bessel functions Neuman polynomial and series. **15 hrs**

Unit 5.*Generating Functions and Orthogonality*: Generating function concept, Generating Function of the form G ($2xt-t^2$), Sets generated by $\varepsilon^t \Psi(xt)$, Generating functions A(t) exp[-xt/(1-t)], Boss and Buck generating Functions, Orthogonality and three term recurrence relation. **15 hrs**

Unit 6.*Legendre polynomials*: Legendre polynomials, Differential equation, Recurrence relations, Rodrigues formula, Hypergeometric form, Laplace integral form and generating functions, orthogonality property. **15 hrs**

Unit 7.*Hermite polynomials*: Hermite polynomials, Recurrence relations, Various representations, Orthogonatily property, Expansions, Generating functions . **15 hrs**

Unit 8.*Laguerre polynomials*: Laguerre polynomials, Rodrigues formula, orthogonality, recurrence retions, Expansions, Generating Functions, Various forms, Properties of Laguerre polynomials, The simple Laguerre polynomials.

15 hrs

Unit 9.*Jacobi Polynomial*: Jacobi Polynomials, Rodrigue's formula, Recurrence relations, Orthogonality property, Appell's functions of two variables, Generating functions. **15 hrs**

Unit 10.*Ultraspherical and Gegenbauer Polynomials*: Ultraspherical and Gengenbauer polynomials, Properies and Relations, Bateman's Polynomial, Rice's Polynomial, Bessel Polynomial. **15 hrs**

Text book:

1. E.D Rainville : Special Functions:, Chelsea Publishing Company New York, 1960.

References books:

1. Talman, J. , W.A. Benjamen : Special Functions, INC New York, 1968.
2. Willard Miller, J : Lie Theory and Special Functions, Academic Press New York,1968.
3. Calson B.C : Special Functions of Applied Mathematics, Academic Press New York, 1977.
4. T.S Chihara,: An introduction to orthrogonal polynomials, Gordon and Breach, Science Publishers, New York.
5. E. T. Whittaker and G.N Watson : A course on modern analysis, Cambridge Univ. Press, 1990
6. Askey, R. : Orthrogonal polynomials and Special Functions, SOC Industr. Appl. Math, Philodelphia, Pennesylvania, 1975.
7. Gabor Szego: Orthogonal Polynomials, AMS, Colloquim Pub. Volume 23 , 1975.

Univalent Functions

Course Title : Univalent Functions
Course No : Math 618
Nature of the Course: Theory
Prerequisite: Math 514 (Theory of Functions)

Full Marks : 100
Pass Marks: 40
Year: II

Course description: This course is designed to acquaint the students with classical aspects as well as recent developments in the theory of univalent functions. Most of the topics of the first two units will be based on `Functions of One Complex Variable' by J. B. Conway; however, for the topic `Poisson integral' we shall follow `Real and Complex Analysis' by W. Rudin and for `Positive Harmonic Functions' `Univalent Functions' by P. L. Duren. Duren's book will be also followed for the remaining eight units.

Course objective:
Upon completion of this course the students will be able to:

- acquire knowledge on classical as well as recent developments in the theory of the univalent functions;
- recognize and appreciate the contribution of the `Bieberbach conjecture' in the inventions of various ingenious tools and techniques of mathematics; and
- acquire basic knowledge for research in Univalent Functions.

Course Contents:

UNIT 1. *Harmonic Functions*: Poisson's Integral, Subharmonic Functions and Superharmonic Functions, Green's Functions, Positive Harmonic Functions. **18 hrs**

UNIT 2. *Range of Analytic Functions*: Bloch's Theorem, Little Picard Theorem, Schottky's Theorem, Great Picard Theorem. **14 hrs**

UNIT 3. *Area Theorem*: Classes S and ε,Some Univalence Criteria, Analytic Green's Formula, Area Theorem, Bieberbach's Theorem, Koebe One-Quarter Theorem. **15 hrs**

UNIT 4. *Growth and Distortion Theorems*: Growth and Distortion Theorems, Bieberbach's Conjecture, Coefficient Estimates (Littlewood's Theorem). **12 hrs**

UNIT 5. *Some Special Classes*: Class P, Convex Functions, Starlike Functions, Close-to-Convex Functions, Spirallike Functions, Typically real Functions. **20 hrs**

UNIT 6. *Parametric Representation of Slit Mappings*: Caratheodory Convergence Theorem, Density of Slit Mappings, Lowener Differential Equations, Univalence of Solutions. **14 hrs**

UNIT 7. *Generalization of Area Principle*: Faber Polynomials, Polynomial Area Theorem, Grunsky's Inequalities, Inequalities of Goluzin and Lebedev. **12 hrs**

UNIT 8. *Exponentiation of Grunsky's Inequalities*: Exponentiation of Power Series, Reformulation of Grunsky's Inequalities, Estimation of nth coefficients, Logarithmic Coefficients. **18 hrs**

UNIT 9. *Subordination*: Basic principles, Coefficient Inequalities. **12 hrs**

UNIT 10. *Subordination contd*: Schwarz-Pick Lemma, Sharpened Form of Schwarz's Lemma, Mazorization. **15 hrs**

Text books:

1. John B. Conway,: *Functions of one Complex Variable, Second Edition*, Narosa Publishing House, New Delhi 1980.
2. P. L. Duren,: *Univalent Functions*, Springer Verlag 1983.

Reference Books:

1. L. V. Ahlfors,: *Complex Analysis, Third Edition*, McGraw-Hill Book Company 1979.
2. C. Pommerenke,: *Univalent Functions*, Vandenhoeck & Ruprecht in Guttingen und Zurich 1975.
3. W. Rudin,: *Real and Complex Analysis, Third Edition*, McGraw-Hill Book Company 1987.

Partial Differential Equations

Course Title : Partial Differential Equations — Full Marks : 100
Course No : Math 619 — Pass Marks: 40
Nature of the Course: Theory — Year: II

Course description: Most of the physical problems of science, engineering and technology can be described in general by (PDEs.). For solving physical problems study of Partial Differential Equation is essential. So this course is designed to give the idea about method of describing the physical problems.
This course consists of 10 units. Unit 1 consists of dimensional analysis and scaling. These are the basic in the theory and practice of mathematical modeling. Unit 2 consists of Perturbations. A perturbation method helps to obtain an approximate solution to a problem when the model equations have terms that are small. Units 3 – 10 consist of types, classification, boundary conditions and methods of solving PDEs.
The units 1, 2 and 6 can be found in book [1], others can be found in and [2].

Course objectives: The objective of this course is to enable the students; to gain the basic idea about the applications and formations of PDE in various branches of science, engineering and technology. They will also made familiar with the Mathematical modeling of the physical problems arising in various branches of science, engineering and technology. The students will be made familiar with the different methods of solving PDEs.

Course Contents:
UNIT 1. *Dimensional analysis and scaling*: Dimensional variable and parameter, Scaling, Asymptotics. **13 hrs.**
UNIT 2. *Perturbation methods:* Regular perturbation method, Singular perturbation method. **15 hrs.**
UNIT 3. *Partial Differential Equations PDEs*: Definitions usefulness and kinds of PDEs., Method of solving PDEs., Classification of second order PDEs.: Canonical form for Parabolic equations, Canonical form for Hyperbolic equations, Canonical form for Elliptic eqautions. **13 hrs.**
UNIT 4. *Parabolic Equations (Diffusion Type Problems):* The Mathematical model of the heat flow experiment, Boundary conditions for diffusion type problems, Derivation of the heat equation, Elementary solution of diffusion equation, Dirac Delta function, Separation of variables, Solution of diffusion equation in cylindrical coordinates, Solution of diffusion equation in spherical coordinates. **18 hrs.**
UNIT 5. *Hyperbolic Equations*: The one dimensional wave equation, The D'Alemberts solution of the wave equation, Boundary conditions associated with the wave equation, Separation of variables. **15 hrs.**
UNIT 6. *Wave propagation in continuous systems*: Wave propagation, The method of characteristic for linear and non linear waves, Quasi - linear equations. **15 hrs.**

UNIT 7. *Elliptic Equations*: Derivation of Laplace equation, The Laplacian (an intuitive description), Derivation of Poisson equation, General nature of the boundary value problems, Some properties of mathematical tools, Properties of Harmonic functions: The spherical mean, Mean Value theorem for Harmonic functions, Maximum – minimum principle and consequences. Separation of variables. **18 hrs.**

UNIT 8. *Elliptic Equations (Continued)*: Dirichlet problem for a rectangle, The Neumann problem for a rectangle, Laplace equation in cylindrical coordinates, Laplace equation in spherical coordinates. **10 hrs.**

UNIT 9. *Fourier Transform Methods*: Fourier series, Sine and cosine series, Fourier integral theorem, Sine and cosine integral representations, Fourier Transform pairs, Transform elementary functions, Properties Fourier Transform, Solution of Diffusion equation, Solution of wave equation, Solution of Laplace equation. **17 hrs.**

UNIT 10. *Laplace Transform Methods*: Introduction to Laplace Transform, Transformations of some elementary functions, Properties of Laplace Transform, Solution of ordinary differential equation, Solution of diffusion equation, Solution of wave equation. **16 hrs.**

Text Books:

1. J. David Logan,: *Applied Mathematics*, John Wiley and Sons.
2. K. S. Rao,: *Introduction to Partial Differential Equations*, Prentice Hall of India.

Reference Books:

1. I. N. Sneddon,: *Elements of Partial Differential Equations*, Mc Graw Hill.
2. Zygmund,: *Trigonometric Series and its Applications*., Cambridge University Press, London.

Dynamics of Viscous Fluid

Course Title : Dynamics of Viscous Fluid — Full Marks : 100
Course No : Math 620 — Pass Marks: 40
Nature of the Course: Theory — Year: II
Pre-requisite: Math 517

Course description: This course is designed to provide to the students an in-depth knowledge and the theoretical background of dynamics of viscous incompressible fluid and its sphere of applications.

Course objectives:
The main objectives of this course are to enable the students:

- to have acquaintance with the theory of Viscous in compressible laminer flow
- to learn the preparatory lessons required to pursue lessions to take their higher study in the subject.

Course Contents:

Unit 1. *Fundamental equations of motion of viscous fluid*: Navier-Stokes Equations of motion, Helmholtz Vorticity equations, Energy dissipation due to viscosity. **15 hrs**

Unit 2. *Exact solutions of the Navier- Stokes equations (Steady incompressible flow):* Flow between two parallel walls-Plane Couette flow, Plane Poiseuille Flow, Flow through circular pipe-the Hagen Poiseuille flow, Flow through an annulus, Flow between concentric rotating circular cylinders. **20 hrs**

Unit 3. *Exact solutions of the Navier-Stokes equations (unsteady incompressible flow):* Flow near the suddenly accelerated wall-Stokes first problem, flow near an oscillating wall-Stokes second problem, unsteady flow between two parallel walls. **15 hrs**

Unit 4. *Law of Similarity*: Reynolds' principle of similarity, Frauds law of similarity, Mach number, Prandtl number, Eckert number, Peclect number and Weber number. **10 hrs**

Unit 5. *Very slow motion (small Reynolds number flows):* Stokes approximation, flow past a sphere, flow past a circular cylinder-Stokes paradox, Oseen approximation. **15 hrs**

Unit 6. *Laminar boundary layer flow*: Prandtl's boundary layer concepts, Boundary layer equations, the boundary layer along a flat plate- the Blasius solution, Shearing Stress and Boundary layer thickness, Similar solution of the boundary layer equations. **15 hrs**

Unit 7. *Exact solutions of the boundary layer eqution*: Flow past a wedge, flow near a forward stagnation point flow, flow in a convergent channel, flow along a flat plate. **15 hrs.**

Unit 8. *Approximate methods to the solution of the boundary layer equations*: Karman momentum integral equation(or condition), Energy integral equation, Application of Karman integral equation to the flow past a flat plate at zero incidence, Karman-Pohlhausen method. **15 hrs**

Unit 9. *Thermal boundary layer in laminer flow*: Derivation of the energy equation, theory of similarity in heat transfer, Analogy between heat transfer and Skin friction, exact solution for the problem of temperature distribution in a viscous flow, Parallel flow past a flat plate at zero incidence. **20 hrs**

Unit 10. *Idea of transition from laminar to turbulent flow*: Transition in pipe and channel flow, Transition in flow along a flat plate, Principle of the theory of stability of laminar flow, Orr-Sommerfild stability equation. **10 hrs**

Text Book:

1. H. Schlichting: *Boundary Layer Theory*, McGraw Hill Book Co.

Reference Books:

1. S. Goldstein: *Modern Development in fluid Dynamics, Vol. I*. Oxford University Press.
2. N.E. Langlois: *Slow viscous flow*, McMillian Co.
3. S.W. Yuan: *Foundation of Fluid Mechanics*, Prentice Hall of India.

Relativity

Course Title : Relativity
Course No : Math 621
Nature of the Course: Theory

Full Marks : 100
Pass Marks: 40
Year: II

Course Description: This course is designed to meet the requirements of the students of the Master level in Mathematics who offers it as a special paper. The only prerequisites for taking this course are a familiarity with calculus, knowledge of differential equations, classical mechanics and electrodynamics. On the completion of this course the students will understand the mathematical methods and physical aspects of the theory of relativity and will be in a position to interpret its implications, and understand literature of this field. The course contains ten units in which the first five units form the special theory: the next two units from tensor calculus and geodesics and the last three units from general theory of relativity.

Course Objectives :
The main objectives of this course are to enable the students:

- to understand the mathematical methods and physical aspects of the theory of relativity.
- to interpret the implications of relativity.
- to take up higher studies.

Course Contents:
Special theory of Relativity.
Unit 1. *Classical theory, Galelian Transformation.*: Transformation equations, Inertial Systems, Law of force, Conservative forces, Galilean transformation, Electrodynamics, Aberration and Doppler effect. **15 hrs**
Unit 2. *The Propagation of light.*: The corpuscular hypothesis , the transmitting medium as the frame of reference, the absolute frame of reference, Fizeau Experiment, The experiment of Michelson and Morley. **15 hrs**
Unit 3. *Postulates of special theory and Lorentz Transformation.*: Simultaneity, postulates of special theory, Lorentz transformation equation, consequences of Lorentz Transformation, composition of velocities, Lorentz transformation as a group, Invariance of velocity of light, Relativistic formula for aberration and Effect. **15 hrs**
Unit 4. *Four Dimensional Continuum.*: Four Dimensional Continuum, space like and time like interval, eigen time, Geometrical view of Lorentz transformation. **15 hrs**
Unit 5. *Relativistic Mechanics.*: Mass and Momentum, relativistic equation of motion and energy, transformation formula for mass, transformation formula for momentum and energy, transformation formula for density, nature of force, transformation formula for force, Hamilton's classical principle, Lagrange's Equations, Hamilton's canonical Equations (classical), Relativistic equation, Keplar's motion. **15 hrs**

Tensor calculus and Geodesics.

Unit 6. *Tensor Calculus.*: Riemanian Space, Covariant and contravariant vectors and tensors, summation convention, symmetric and skew symmetric tensors, contraction, Rigorous Quotient Theorem, fundamental tensors, raising and lowering suffix, associated tensors, Christoffel's three indexed Symbols. **15 hrs**

Units 7. *Geodesics.*: Geodesic and its equations, covariant derivative of vector and tensor, curvature tensor, Properties of curvature tensor, Bianchi identities, condition for a flat space time. **15 hrs**

General theory of Relativity.

Unit 8. *Principle of covariance and principle of equivalence.*: Special theory, principle of covariance and principle of equivalence, clock paradox, Newton's theory as a first approximation. **15 hrs**

Unit 9. *Einstein law of gravitation in empty space.*: Field equation, Schwarz-Schild solution, Planetary orbits, Advance of perihelion, Gravitational deflection of light, gravitational shift in spectral lines **15 hrs**

Unit 10. *Einstein law of gravitation in material world.*: Divergence of a tensor, Fundamental Theorem of mechanics, Material energy tensor, Einstein law of gravitation for material world, static line element with spherical symmetry, Einstein and de Sitter line element, Einstein universe, density and pressure in Einstein universe, de Sitter universe and its nature. **15 hrs**

Text Books:

1. P.G. Bergmann : *Introduction to theory of relativity*, Prentice-Hall, 1979.
2. A.S. Eddington : *The Mathematical theory of Relativity*, Cambridge University, 1965.

Reference Book:

1. M. Ray: *Theory of special and general relativity*, S. Chand and Company, 1980.

Nonlinear programming and scheduling II

Course Title : Nonlinear programming and scheduling II — Full Marks : 100
Course No : Math 622 — Pass Marks: 40
Nature of the Course: Theory — Year: II
Pre-requisite: Math 518

Course Description: This course is about dynamic programming, scheduling modeling-algorithms and nonlinear programming. It is designed to provide the students with an in-depth knowledge of the theoretical as well as practical background. The approach of the course will be mathematical modeling, methods and algorithms. The course relates with operations research, numerical mathematics, theoretical computer science and computing.

Course Objectives:

The main objectives of this course are to enable the students:

- to broaden their mathematical knowledge towards mathematical models, methods and algorithms;
- to realize the importance of various aspects of optimization or scheduling with its applications in everyday experience like industries, agriculture, etc; and
- to be motivated and prepared a for the study of and research on more advanced field of optimization or scheduling.

Course Contents:

UNIT 1. *Primal Methods for Constrained Minimization*: Advantages, Feasible Direction Methods, Active Set, Gradient Projection and Convergence Rate, Reduced Gradient and Convergence, Variations. **15 hrs.**

UNIT 2. *Penalty and Barrier Methods*: Penalty and Barrier, Properties, Newton-Penalty, Conjugate Gradient-Penalty, Normalization, Exact Penalty. **15 hrs.**

UNIT 3. *Dual and Cutting Plane Methods*: Local Duality, Dual Canonical Convergence Rate, Separable Problems, Augmented Lagrangians, Dual View Point, Cutting Plane, Kelley's Algorithm, Modifications. **15 hrs.**

UNIT4. *Lagrange Methods and Algorithms*: Quadratic Programming, Direct Method, Modified Newton Method, Descent Properties and Rate of Convergence, Quasi-Newton Method. **15 hrs.**

UNIT 5. *Dynamic Programming*: Introduction, Nature, Efficiency, Dynamic Programming Problems (Only Models of Decision, Loading, Inventory, Allocation, Two Control Variables, Transportation, Production Scheduling), Continuous Variables and Concave Cases, Linear-Dynamic Programming Comparison. **15 hrs.**

UNIT 6. *Open and Flow Shop Scheduling Algorithms*: The Disjunctive Graph and Block Matrix Models, Arbitrary and unit Processing Times for Open Shop, Minimizing Makespan of Flow Shop **15 hrs.**

UNIT 7. *Job and Mixed Shop Scheduling Problems*: Problems with Two Machines, Problems with Two Jobs, Introduction to Job-Shop with Two Machines and Branch-Bound Algorithm. **15 hrs.**

UNIT 8. *Due-Date Scheduling*: Single Machine Problems with dopt and d, Tardiness, Lateness, Earliness Objectives. **15 hrs.**

UNIT 9. *Batching, Changeover Times (CT) and Transportation Times (TT):* Single Machine Batching Problems, Single and Parallel Machine Problems for CT and TT, General Shop for CT and TT. **15 hrs.**

UNIT 10. *Multiprocessor Tasks (MPT) and Multi-Purpose Machines (MPM):* MPT Systems, Shop Problems with MPT for unit Processing and Introduction to Arbitrary Processing Times, MPM with Identical and Uniform Machines, MPM with unit Processing Times and Introduction to Arbitrary Processing Times. **15 hrs.**

Text Books:

1. G. Hadley: *Nonlinear and Dynamic Programming*; Addison-Wesley.
2. Peter Brucker: *Scheduling Algorithms*; Springer Verlag, 1995.
3. David G. Luenberger: *Linear and Nonlinear Programming*; Addison-Wesley, 1984.

Reference Books:

1. P. E. Gill and W. Murray : *Numerical Methods for Constrained Optimization*; Academic Press New York.
2. M. S. Bazaraa et al. : *Nonlinear Programming Theory and Algorithms*; John Wiley.
3. Karl-Heinz Elster: *Modern Mathematical Methods of Optimization*; Springer Verlag, 1993.
4. E. Pesch, K. H. Echer et al. : *Scheduling Computer and Manufacturing Processes*; Springer Verlag 1996.
5. V. S. Tanaev et al. : *Scheduling Theory Multi-Stage Systems,* Kluwer Academic Pub, Dordrecht, 1994.
6. V. S. Tanaev et al. ; *Scheduling Theory Single-Stage Systems*; Kluwer Academic Pub, Dordrecht, 1994.

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Numerical Analysis

Course Title : Numerical Analysis — Full Marks : 100
Course No : Math 623 — Pass Marks: 40
Nature of the Course: Theory — Year: II

Course Description: This course is about numerical linear algebra, numerical differential equations and numerical analysis. It is designed to provide to the students an in-depth knowledge of the theoretical as well as practical background. The approach of the course will be mathematical methods, analysis and algorithms. The course relates with algebra, analysis and applied mathematics.

Course Objectives

The main objectives of this course are to enable the students:

- to broaden their mathematical knowledge towards numerical methods and algorithms;
- to realize the importance of various aspects of numerical analysis and its applications in everyday experience like industries, agriculture, etc; and
- to be motivated and get prepared for the study and research on more advanced field of numerical mathematics.

Course Contents:

UNIT 1. *Interpolation and Approximation*: Interpolation by Polynomials, Rational and Spline Functions, Errors. **15 hrs.**

UNIT 2. *Numerical Integration*: Integration Formula of Newton and Cotes, Peano's Error Representation, Euler-Maclaurin Summation Formula, Gaussian Integration Methods. **15 hrs.**

UNIT 3. *Linear System Solving*: Gauss Elimination Algorithm, Triangular and Cholesky Decompositions, Gauss-Jordan Algorithm, Basic Error Bounds, Householder and Gram-Schmidt Process. **15 hrs.**

UNIT 4. *Linear System Solving and Iteration*: Data Fitting, Modification Techniques for Matrix Decompositions, General Properties for the Construction of Iterative Methods, Convergence of Iterative Methods . **15 hrs.**

UNIT 5. *Finding Zeros by Iterative Methods*: Development, General Convergence, Newton and Modified Newton Methods, Roots of Polynomials as Application of Newton's Method. **15 hrs.**

UNIT 6. *Finding Zeros and Large System Solving by Iteration*: Strum Sequence and Bisection Methods, Interpolation Methods, Method of Aitken, Relaxation and Conjugate Gradient Methods for Solving Large Systems of Linear Equations by Iteration. **15 hrs.**

UNIT 7. *Eigenvalue Problems*: Introduction, Basic Facts, Jordan Normal Form, Frobenius Normal Form, Schur Normal Form, Hermitian Normal Matrices, Singular Values of a Matrix, Introduction to Reduction of Some Matrices to Simpler Form. **15 hrs.**

UNIT 8. *Eigenvalue Problems (Contd.)*: Methods for Determining Eigenvalues and Eigenvectors, Computation of the Singular Values of a Matrix, Generalized Eigenvalues, Introduction to Estimation of Eigenvalues. **15 hrs.**

UNIT 9. *Numerical Methods for ODE's Initial Value Problems*: Introduction, Initial Value Problems, One–Step Methods and Convergence, Multi-Step Methods and Convergence. **15 hrs.**

UNIT 10. *Numerical Methods of Differential Equations*: Introduction to Boundary Value Problems, Simple and Multiple Shooting Methods, Difference Method, Variational Method for ODE's.

15 hrs.

Text Book:

1. J. Stoer and R. Bulirsch: *Introduction to Numerical Analysis*; Springer Verlag.

Reference Books:

1. Conte de Boor: *Elementary Numerical Analysis*; McGraw-Hill.
2. Erwin Kreyszig: *Advanced Engineering Mathematics*; New Age International (P) Ltd.

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