GULBARGA UNIVERSITY
KALABURAGI

FACULTY OF SCIENCE & TECHNOLOGY

Syllabus for
MASTER OF SCIENCE
IN
MATHEMATICS
(CBCS SCHEME)

(With effect from Academic Year 2017-18 And Onwards)

DEPARTMENT OF POST-GRADUATE STUDIES & RESEARCH IN MATHEMATICS
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**Soft Core Course (Any One)**

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## SECOND SEMESTER

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Total Number of Credits: 24
Preamble: The aim is to provide the development of subject-matter which is honest, rigorous and at the same time not too pedantic. Most of the hard theorems which are either omitted or treated rather simply in many texts in advanced analysis are proved with care. Some of them are ordinarily considered too difficult for a course of analysis. With the inclusion of these theorems the syllabus attempts to fill the gap and to make the transfer from elementary calculus to advanced course in analysis as smooth as possible. The syllabus starts with a quick review of the essential properties of rational numbers. The Dedekind’s Cut properties of real numbers are established. This foundation supports the subsequent chapters: topological framework, sequences and series of numbers, continuity, differentiation, elementary functions, Riemann integration, with a quick look at the Riemann-Stieljes integral and finally the functions of several variables and the implicit functions.

1. The Riemann-Stieltje’s Integral: Definition and existence of the integral, properties of the integral, change of variable, integration and differentiation, integration of vector valued functions, rectifiable curves.
   (15 Hours)

2. Sequence and Series: Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, uniform convergence and bounded variations, equicontinuous families of functions, The Stone-Weierstrass theorem.
   (14 Hours)

3. Power Series: Definition of power series, the exponential and logarithmic functions, the trigonometric functions, Fourier series, trigonometric series, Parseval’s theorem, the gamma functions.
   (15 Hours)

4. Functions of Several Variables: Linear transformations, differentiation, the contraction principle, the inverse function theorem, the implicit function theorem, the rank theorem illustration and examples.
   (20 Hours)

References:
Preamble: Algebra frequently provides a student's first encounter with an abstract mathematical discipline, a secondary objective is to sow the seeds from which a modern mathematical attitude may grow. Mastery of this syllabus constitute a firm foundation for more specialized work in algebra and also should be of great help in any further axiomatic study of mathematics.

1. Groups: conjugate elements, conjugate class, normalizer of an element of a group, center of a group, quotient groups, direct products, Cauchy's theorem for Abelian group. (10 Hours)

2. Sylow's theorems, p-group, Sylow p-group, finite Abelian group, exponent of a group, solvable groups, Schreier's refinement theorem. (20 Hours)

3. Rings: Field of quotients of an integral domain, Euclidean rings, properties of Euclidean ring. Unique factorization domain, polynomial rings over unique factorization domains, Gauss lemma, Eisenstein's criterion. (20 Hours)

4. Field: Extension of fields, algebraic extensions, factor theorem. Splitting field, separable and inseparable extensions, Finite field, perfect field. (14 Hours)

References:


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Preamble: the course has been designed for the use of post graduate students according to the latest semester system and unified syllabus prescribed by U.G.C for all Indian Universities. Besides it will also be very helpful for those students preparing for various competitive examinations. We have fully understood the need of the students and hence we have tried our level best to provide clear concepts of
each unit, the subject matter, illustrations and exercises. We tried to put the subject matter in our own way from the student’s point of view.

1. **Basic Theory of Differential Equations and Wronskian**: Introduction, Differential Equations and their Classification, Function of Two Real Variables, the Lipschitz Condition, Basic theory of the homogeneous Linear Differential Equations, The Wronskian, Fundamental Set, Initial Value Problem, Existence and Uniqueness Theorems. (12 Hours)


4. **Orthogonal Sets of Functions and Strum – Liouville Problem**: Orthogonality, Orthogonal set of function, Orthonormal set of functions, Orthogonality with respect to a weight function, Orthogonal set of functions with respect to a weight function, Orthonormal set of functions with respect to a weight function, working rule for getting orthonormal set, Strum – Liouville problem, Eigen (or characteristic) functions and eigen (or characteristic) values, Orthogonality of eigenfunctions, Reality of eigenvalues, Examples. (26 Hours)

**References:**


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Preamble: Discrete mathematics is a part of Mathematics developed to study discrete objects and relationships among them. It is a fundamental component of Mathematics and computer science. It is a hybrid course. Its content is Mathematics, but many of its applications are from computer science. It helps students to extend mathematical maturity and ability to deal with abstraction, Combinatorics, algorithms and its analysis and graphs. The concepts which are to be studied in this paper serve as a foundation upon which many other courses in computer science are built. The present paper includes topics from set theory, Combinatorics, mathematical logic, graph theory and algebra which are considered basic and useful to students of applied Mathematics.

1. **Logic**: Propositions and Logical Operations, conditional statements, methods of proof, mathematical induction. *Combinatorics* - Basic counting principles, permutations, combinations, Pigeonhole principle, principles of inclusion and exclusion, elements of probability. (16 Hours)

2. **Recurrence relations**: Discrete numeric functions, manipulation of numeric functions, generating functions, recurrence relations, linear recurrence relations with constant coefficients, homogeneous solutions, particular solutions, total solutions, solution by the method of generating functions. (16 Hours)

3. **Lattices and Boolean Algebra**: Binary relations and its properties, partially ordered sets, Lattices, distributive and complemented lattices, Boolean lattice and Boolean algebra, uniqueness of Boolean algebra, Boolean functions and Boolean expressions, design and implementation of digital networks, switching circuits. (16 Hours)

4. **Groups and Coding**: Monoids, Groups, subgroups, cosets and Lagrange's theorem, permutation groups. *Codes and group codes* - Coding of binary information and Error detection, decoding and error correction. (16 Hours)

References:


### Paper: ICT 1.5 General Topology

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Preamble: Nowadays, studying general topology really more resembles studying a language rather than mathematics: one needs to learn a lot of new words, while proofs of most theorems are extremely simple. On the other hand, the theorems are numerous because they play the role of rules regulating usage of words. The subject of topology is of interest in its own right, and it also serves to lay the foundations for
future study in analysis, in geometry, and in algebraic topology. There is no universal agreement among mathematicians as to what a first course in topology should include; there are many topics that are appropriate to such a course, and not all are equally relevant to these differing purposes. In choice of material to be treated, the framed syllabus tries to strike a balance among the various points of view.

1. **Topological Spaces**: Definition of a topology, Types of topologies, neighborhoods, limit point, closure, interior and boundary of a set, Base, sub-base, subspace, continuous map, open and closed maps, homeomorphism. (15 Hours)

2. **Separation Axioms**: $T_0$, $T_1$, $T_2$ spaces, Regular space, Normal space, Urysohn’s characterization of normality, $T_3$, $T_4$, $T_5$ spaces, countability Axioms, separable space, convergence of a sequence. (24 Hours)

3. **Connectedness**: Connected and disconnected spaces, components, connectedness and continuous map; **Compactness**: Cover, subcover, compactness, characterizations, Heine-Borel theorem, compactness and continuous map, finite intersection property, one point – compactification. (15 Hours)

4. **Metric Space**: Metric on a set, open spheres, topology induced by a metric, equivalent metric spaces, diameter, continuity. **Lindelof Space**: Lindelofness and countability, continuity and other properties of Lindelofness. (10 Hours)

References:

Preamble: The subject of Operations Research has been growing theoretically and has a wide ranging applications in the field of life namely engineering, business, management, economics and medical sciences etc. In view of this, a course of Operations Research is introduced to the students of Mathematics as a job-oriented course. The main aim of this paper is to introduce the fundamentals of operations research and its techniques used in different fields of interest and greater use of these tools in planning, scheduling, cost and job control for the efficient and economical conduct of industrial Endeavour.

1. Linear Programming: Basic concept, convex sets, open and closed half spaces, simplex formulation of linear programming problem (LPP), feasible solution, basic feasible solution, optimal solution, graphical method, simplex method. Artificial variables, method of penalty and two-phase simplex method. (20 Hours)

2. Duality in linear programming: concept of duality, properties, fundamental theorem of duality, dual simplex method. (12 Hours)

3. Transportation problem (PT): Mathematical formulation, existence of feasible solutions, transportation table, initial basic feasible solution; North-west corner rule, row minima method column minima method, matrix minima method, Vogel’s approximation Method (VAM) Transportation algorithm, degeneracy in TP, unbalanced TP. (16 Hours)


Networks: Network minimization, shortest route problem, shortest rout algorithms for acyclic timeworks, maximal, flow problem, linear programming representation of networks. (16 Hours)

References:

Preamble: Fuzzy theory has become a subject that generates much interest among students of mathematics and engineers. The main objective of this paper is to introduce basic and concrete concepts of fuzzy theory and its applications.

   (20 Hours)

   (20 Hours)

   (12 Hours)

   (12 Hours)

References:


3. Drankov D, and others. An Introduction to Fuzzy control.

4. B. Kosko & others, Fuzzy logic with Engineering Applications. PHI
Preamble: The course on PDE gives a really comprehensive introduction to all those parts of the theory of PDE that are needed in practical applications of that theory, whether in the physical sciences or in the different branches of engineering. The course is also set out excellently as a body of mathematical analysis of wide general interest. All the essential ideas of the subject are explained with great clarity. We can particularly admire the way in which ideas are first introduced in relatively simple cases and then gradually extended to more complicated cases and to more advanced applications.


5. **Non – Linear Partial Differential Equations of Second Order**: Introduction, Monge’s Method of Integrating $Rr + Ss + Tt = V$, Working Method of the Equation $Rr + Ss + Tt = V$, Monge’s Method of Integrating $Rr + Ss + Tt + U \left( rt - s^2 \right) = V$, Working Method of the Equation $Rr + Ss + Tt + U \left( rt - s^2 \right) = V$. 


V, when the roots of the quadratic are identical, Working Method of the Equation \( Rr + Ss + Tt + U (rt - s^2) = V \), when the roots are distinct. (10 Hours)

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Preamble: The main goal of classical algebra was to use algebraic manipulation to solve polynomial equations in one variable of degree at most four. It also developed methods for dealing with linear equations containing several variables, but little was known about the solution of non linear equations. The most useful mathematical tool in science, engineering and the social science is the method of solution of a system of linear equations together. All its allied Linear algebra.

1. Linear Algebra: Linear transformation, algebra of linear transformations, characteristics roots, interpretation in terms of matrices. (15 Hours)
2. Canonical Form: Triangular, Nilpotent, Jordan and rational, trace, transpose and the determinant of linear transformations. (10 Hours)
3. Functionals and Dual Spaces: inner product spaces, orthogonal sets, Hermitian, Unitary and normal transformation, bilinear, quadratic and Hermitian forms. (15 Hours)
4. Number Theory: Linear Diophantine equation, quadratic congruence's. (12 Hours)
5. Quadratic Residues: Sum of two squares, sum of more than two squares, Tau and sigma functions, Fibonacci sequence, finite continued fractions. (12 Hours)

References:

### Paper: HCT 2.3 Programming in C

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**Preamble:** This paper introduces computer programming to a beginner using the programming language C. The version of C used is the one standardized by the American National Standards Institute (ANSI C). C has rapidly gained users due to its efficiency, rich data structure, variety of operators and affinity to UNIX operating system. C is a difficult language to learn if it is not methodically approached. Our attempt has been to introduce the basic aspects of C to enable the student to quickly start writing C programs.

1. **Introduction:** Introduction to Computers, Characteristics of Computers, Application Areas of Computer, Classification of Computers, Overview of Programming, Types of Programming Languages, Introduction to C, Features of C, Program Structure, Concept of Header File, Preprocessor, Character Set, Identifiers, Reserved Words, Constants and Variables, Data Type, Modifiers, Types of Statements, Declaration and Initialization, Comments. (12 Hours)

2. **Type of I/O Statements:** Formatted and Unformatted I/O Statements, Escape Sequences and Format Specifications. Types of Operators (unary, binary and ternary), Classification of Operators: Assignment, Arithmetic, Relational, Logical, Comma Operator, Size of Operator, Operator, Hierarchy and Associativity, Type Conversion explicit and implicit, Library Functions. (16 Hours)

3. **Control Statements:** If, If Else, Switch Statements, Looping Statement (for, while, do while), Nested Loops, Infinite Looping, Break and Continue. (12 Hours)

4. **Classification of Arrays:** One, Two and Multidimensional Arrays, Function Definition, Arguments and Parameters, Category of Functions, Arrays iv Functions, Local and Global Variables, Static and Register Variables, Function Declaration, Parameter Passing Mechanisms, Recursion. (12 Hours)

5. **Strings:** Declaring and Initializing String Variables, Reading and Writing Strings, Two-Dimensional array of Characters, String Handling Functions, Implementation of String Functions. Pointer Declaration, Pointer Dereferencing, Operations on Pointers, Pointer Initialization, Pointers and Functions. (12 Hours)

**References:**
4. Balguruswamy: Programming in ANSI C.
5. Yeshwant Kanetkar: Let US C.

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<td>Maximum Marks: 100 (SEE-80 + IA-20)</td>
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</table>

Preamble: The study of complex analysis is beautiful from a mathematical point of view and it provides a powerful tool for solving several problems arising in real applications. Mathematicians, scientists and engineers often resort to the “complex plane” while explaining the real phenomena. Using complex analysis one can solve many problems that are either very difficult to solve or impossible to solve by other means. The present syllabus is designed for the post graduate students to understand the basic concepts of complex analysis and also to equip them with complex analysis tools to find the solutions of complex problems.

1. Analytic Function: (Recapitulation) Functions of Complex Variables, Mappings, Limits, Continuity, Derivatives, C-R Equations, Analytic Functions. (5 Hours)

2. Complex Integration: Complex Valued Functions, Contours, Contour Integrals, Cauchy – Gourat Theorem, Cauchy integral Formula, Morera’s Theorem, Louville’s Theorem, Fundamental Theorem of Algebra. (15 Hours)


5. Spaces of Analytic Functions, Spaces of Meromorphic Functions, The Riemann Mapping Theorem, Weierstrass Factorization Theorem, Schwartz Reflection Principle. (15 Hours)

References:


<table>
<thead>
<tr>
<th>Paper: SCT 2.2 Fuzzy Logic and Applications</th>
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<tbody>
<tr>
<td><strong>Teaching Hours:</strong> 4 Hrs/Week</td>
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<tr>
<td><strong>Maximum Marks:</strong> 100 (SE-80 + IA-20)</td>
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</table>

**Preamble:** Fuzzy logic has wide ranging applications in science and engineering. The goal of this paper is to introduce fuzzy logic and its applications to post graduate students in Mathematics so that they can develop a reasonably in-depth understanding of the principle and the practice of technology as well as a working of how to use the technology themselves.

1. **Fuzzy Relations:** Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy ordering relations, Fuzzy morphisms, Sup-I compositions of fuzzy relations, Inf- $w'$ compositions of Fuzzy relations. (14 Hours)

2. **Fuzzy Relation Equations:** Introduction, Problem partitioning, Solution method, Fuzzy relation equations based on Sup-I compositions and Inf- $w'$ compositions, approximate solutions. (10 Hours)

3. **Fuzzy Logic:** Classical logic an overview, multi valued logics, Fuzzy propositions, Fuzzy quantifiers, Linguistic hedges, inferences from conditional fuzzy propositions and qualified propositions and quantified propositions. (20 Hours)

4. **Applications of Fuzzy Sets and Logic:** Signal processing, image processing, hand written character recognition and visual image recognition, Communications systems, intelligent controller, other applications. (20 Hours)

**References:**

1. George J. Klor. and Yuan, Fuzzy sets and Fuzzy logic, Theory and Applications. PHI.
4. Driankov D, and others. An Introduction to Fuzzy control.
5. B. Kosko & others, Fuzzy logic with Engineering Applications. PHI

<table>
<thead>
<tr>
<th>Paper: OET 2.1 Operations Research-I</th>
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<tbody>
<tr>
<td>Teaching Hours: 5 Hrs/Week</td>
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<tr>
<td>Credits : 06</td>
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<tr>
<td>Tutorial Hours: 1 Hr/Week</td>
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<tr>
<td>Maximum Marks: 100 (SEE-80 + IA-20)</td>
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</table>

Preamble: The subject of Operations Research has been growing theoretically and has a wide ranging applications in the field of life namely engineering, business, management, economics and medical sciences etc. In view of this, a course of Operations Research is introduced to the students of Science as a job-oriented course. The main aim of this paper is to introduce the fundamentals of operations research and its techniques used in different fields of interest and greater use of these tools in planning, scheduling, cost and job control for the efficient and economical conduct of industrial Endeavour.

1. Linear Programming: Basic Concepts, Convex Sets, Open and Closed Half Spaces, Simplex, Formulation of Linear Problem (LPP), Feasible Solution, Basic Feasible Solution, Optimal Solution, Graphical Method, Simplex Method. (16 Hours)

2. Transportation Problem (TP): Mathematical Formulation, Existence of Feasible Solutions, Transportation Table, Initial Basic Feasible Solution; North-West Corner Rule, Row Minima Method, Column Minima Method, Matrix Minima Method, Vogel's Approximation Method (VAM), Transportation Algorithm, Degeneracy in TP; Unbalanced TP. (16 Hours)

3. Assignment Problem: Mathematical Formulation, Assignment Algorithm, Routing Problem, Traveling Salesmen Problem. (12 Hours)

4. Networks: Network Minimization, Shortest Route Problem, Shortest Route Algorithms for Acyclic Networks, Maximal Flow Problem, Linear Programming Representation of Networks. (12 Hours)
5. Integer Programming: Methods of Integer Programming Problems; Cutting Method, Search Method, Gomory's Fractional Cut Algorithm Mixed Integer Programming Problem, Branch and Bound Methods. (08 Hours)

References:

Preamble: The development of the subject “Functional Analysis” started at the beginning of the last century and has grown tremendously during the past few decades. The fundamental concepts gradually emerged from the classical analysis and began to establish rapidly and hence attracted the attention of Mathematicians. The roots of this subject lie in the concepts of older elementary analysis and the connected branches of algebra and geometry. The development of newer concepts embodies the abstract approach enabling to study classes of functions rather than individual functions. The study of Functional Analysis is an essential part of the post graduate students in Mathematics.

1. Metric Spaces: Open Sets, Closed Sets, Bounded Sets, Convergence, Continuity, Compactness, Connectedness, Completeness and Bair’s Theorem, Cantor’s Intersection Theorem, Weierstrass Approximation Theorem, Spaces of Continuous Function. (14 Hours)

2. Banach Space: Continuous Linear Transformation, Dual Spaces, Hahn Branch Theorem, The Nature Embedding of Normed Linear Space into its Second Conjugate Space, The Open Mapping Theorem, Closed Graph Theorem. The Conjugate Operator, Banach Steinhans Theorem. (20 Hours)


4. Finite Dimensional Spectral Theory: Matrices, determinants and the spectrum of an operator, spectral theorem. (10 Hours)

References:


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Paper : HCT 3.2 Graph Theory – I

Teaching Hours: 4 Hrs/Week

Credits : 04

Maximum Marks: 100 (SEE-80 + IA-20)

Preamble: Graph Theory is particularly suited to selective study and this syllabus here provides materials for individual to tailor to their courses requirements. A blend of the theory with some of its many varied applications of graphs is highly desirable for both disciplines.

1. Graph: Basic properties, component, isomorphism, regular graph, complement of a graph, self-complementary graphs. Operations on graphs. Planar graph, Combinatorial and geometric graphs
detection of planarity, subdivision of a graph, inner vertex set and number, geometric dual of graph and its properties, crossing number and thickness of a graph.  

(18 Hours)

2. **Coloring, covering and independence**: Coloring, color class, chromatic number, bichromatic number, vertex coloring algorithm, simple sequential algorithm, smallest last sequential algorithm, cliques edge–coloring n-edge coloring of a plane map. Uniquely colorable graph, covering number, edge covering number vertex independence number, edge independence  

(22 Hours)


(10 Hours)

4. **Directed graphs**: Digraph, kinds of digraphs, weekly connected, strongly connected digraphs, Euler digraph, tournaments, directed trees, arborescence, condensation of a digraph.  

(14 Hours)

**References:**


<table>
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<tr>
<th>Paper : HCT 3.3 Computational Numerical Methods - I</th>
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<tr>
<td>Teaching Hours: 4 Hrs/Week</td>
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**Preamble:** In the process of problem solving it is possible to distinguish several distinct phases like mathematical formulation, selection of numerical method for its solution and implementation of these numerical methods on a computer. The phenomenal development of computers during the last few decades has helped the scientists and engineers in solving very complicated problems in terms of their complexity and the amount of information to be processed. Applied mathematicians, scientists and engineers are to be equipped with the computational techniques for solving the problems arising under new situations in the future. The aim of this course is to study several computational methods such as functional approximations, solutions of non-linear equations and matrix algebra and also to give hands-on experience of implementation of these numerical methods on a computer using C-language.

1. **System of Nonlinear Equations**: Newton-Raphson method, general Iteration method; Polynomial Equations- Descartes’ Rule of signs, Iterative Methods- Birge-Vieta method, Bairstow method, Muller’s method, Direct Method- Graffe’s root squaring method.  

(14 Hours)

2. **Interpolation and Approximation**: Gregory-Newton forward difference interpolation, Gregory-Newton backward difference interpolation, Sterling and Bessel interpolations, Hermite interpolation, Piecewise and spline interpolation- linear, piecewise quadratic, piecewise cubic interpolation, spline interpolation, quadratic spline interpolation, cubic spline interpolation.  

(15 Hours)


References:


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<tr>
<th>Paper : HCP 3.3 Computational Numerical Methods - I</th>
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<td>Teaching Hours: 2 Hrs/Week</td>
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<td>Maximum Marks: 50 (SEE-40 + IA-10)</td>
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List of Experiments: Students have to implement the following numerical methods by using C programming language

1. Numerical solution of transcendental and polynomial equations:
   - Bisection method
   - Newton-Raphson method
   - Muller Method

2. Interpolation:
   - Generation of forward difference table, backward difference table, central difference table for the given set of tabular values \((x_i, y_i)\) \(i = 0, 1, 2, 3, \ldots, n\).
   - Lagrange's interpolation formula (for unevenly spaced points)
   - Newton's forward difference and backward difference formula (for evenly spaced points)

3. Numerical solution of system of linear algebraic equations:
   - Gauss elimination method
   - Gauss-Jordan elimination method
   - Jacobi method
   - Gauss-Seidal method
Paper: OET 3.1 Operations Research – II

Teaching Hours: 5 Hrs/Week
Tutorial Hours: 1 Hr/Week

Credits: 06

Maximum Marks: 100 (SEE-80 + IA-20)

Preamble: The subject of Operations Research has been growing theoretically and has a wide ranging applications in the field of life namely engineering, business, management, economics and medical sciences etc. In view of this, a course of Operations Research is introduced to the students of Science as a job-oriented course. The main aim of this paper is to introduce the decision models and its techniques used in different fields of interest and greater use of these tools in planning, scheduling, cost and job control for the efficient and economical conduct of industrial Endeavour.


(16 Hours)


(16 Hours)

3. Queuing Theory: Introduction, Queue discipline, Service channels, Poisson process, distribution of Inter-arrival times and Service times, classification of queues, Poisson queues, and M/M/1 queuing models.

(16 Hours)

4. Simulation: Introduction, elements of simulation model, Event-Type simulation, Generation of random phenomena, Monte-Carlo technique, Generation of uniform and non-uniform random observations, steps in simulation, simulation languages.

(16 Hours)

References:


Paper: SCT 3.1 Fluid Mechanics - I

Teaching Hours: 4 Hrs/Week

Credits: 04

Maximum Marks: 100 (SEE-80 + IA-20)

Preamble: Fluid mechanics is that branch of science which deals with the behavior of the fluids (Liquids or gases) at rest as well as in motion. Thus this branch of science deals with the static, kinematics and
dynamic aspects of fluids. This field of mechanics obviously encompasses a vast array of problems that may vary from the study of blood flow in a capillaries to the flow of crude oil across Alaska through an 800-mile long, 4 feet diameter pipe. Fluid mechanics principles are needed to explain why airplanes are made streamlined with smooth surfaces for the most efficient flight, whereas golf balls are made with rough surfaces (dimpled) to increase their efficiency. As this branch of Mathematics is closely related with the real world problems. The Students will have a good exposition to implement mathematics in solving and doing modellings which occurs in geohydrology, aeronautics, biomechanics, medicine, turbines etc.

1. Kinematics: Lagrangian method, Eulerian method, local and individual time rates of change, stream line, path line, streak line, velocity potential, boundary surface, Eulerian and Lagrangian equations of continuity, equations of continuity in different co-ordinates, symmetrical forms of equations of continuity. (10 Hours)

2. Equations of Motion: Equations of motion, pressure equation, Bernoulli’s equation, Lagrangian equation of motion, Helmholtz vorticity equation, equations for impulsive action, Kelvin circulation theorem, irrotational motion in two dimensions, sources, sinks, complex potential, image with respect to a straight line, image with respect to a straight line, image with respect to a circle, Milne-Thomson circle theorem, Dibius theorem. (20 Hours)

3. Motion of Cylinders: General motion of any cylinder, motion of a circular cylinder, application of circle theorem, initial motion between two co-axial cylinders, kinetic energy of liquid, streaming and circulation about a fixed circular cylinder, equation of motion of circular cylinder with circulation. (20 Hours)

4. General Theory of Irrotation Motion: Irrotational motion, kinetic energy of finite liquid, kinetic energy of infinite liquid, Kelvins minimum energy theorem, mean value of potential function, Greens theorem. (14 Hours)

References:


<table>
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<tr>
<th>Paper : SCT 3.2 Classical Mechanics</th>
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<td>Credits : 04</td>
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<td>Maximum Marks: 100 (SEB-80 + IA-20)</td>
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Preamble: The subject “Classical Mechanics” is the oldest branch of physics which deals with the description and explanation of the motion of point-like as well as extended, rigid as well as deformable
objects embedded in a three dimensional Euclidian space. In this course students will study the geometrical description of the motion. Some of the greatest minds of all times such as Sir Isaac Newton, Joseph Lagrange, Leonhard Euler, Sir William Hamilton laid the foundation and built the theoretical structure of the subject.


2. Energy equation for conservative field; Generalized momenta and Hamilton's canonical equations. Rigid body and Eulerian angles, infinitesimal rotation. Coriolis theorem. Motion relative to rotating earth, Euler's dynamical equations of motion of a symmetrical top. (10 Hours)


4. Cyclic co-ordinates, Rout's equation, Poisson's bracket, Poisson's identity, Lagrange's Bracket. Condition of canonical character of a transformation in terms of Lagrange's bracket, Poisson's bracket. Invariance of Lagrange's brackets and Poisson brackets under canonical transformations. (20 Hours)

Reference Books:

2. F. Gantmacher, Lectures in Analytical Mechanics, MIR Publisher, Mascow, 1975.

<table>
<thead>
<tr>
<th>M. Sc. Fourth Semester</th>
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<tr>
<td><strong>Paper : HCT4.1 Measure Theory</strong></td>
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<tr>
<td><strong>Teaching Hours:</strong> 4 Hrs/Week</td>
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<td><strong>Maximum Marks:</strong> 100 (SEE-80 + IA-20)</td>
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</table>
Preamble: The subject being very modern in nature, all needed definitions have been given at the beginning of the chapters, and though apparently the volume looks very thin but it covers the entire course as laid down in various Indian Universities. It is needless to emphasize that the style adopted in this syllabus is lucid, clear, easy, and clearly understandable to the students. A good many solved and unsolved examples have been given in every chapter so that students may have enough practice in the subject.

1. Measure and Outer Measure: Ring of a set, $\sigma$-ring of sets, algebra of sets, $\sigma$-algebra of sets, measure space, Caratheodory’s postulates of outer measure, measurable set, problems related to measure function, ring of sets, $\sigma$-algebra of sets and Lebesgue measure of a set, Exterior and interior measure, Vitali’s covering theorem, Borel measurable set. (20 Hours)

2. Measurable Functions: Measurable function, Almost everywhere, equivalent function characteristic function, Borel measurability of functions, Little wood’s three principles, Lebesgue integral of a function, first mean value theorem. (14 Hours)

3. Convergence in measure, Reisz’s theorem, D.F. Egoroff’s theorem, Lebesgue, bounded convergence theorem, Fatou’s lemma, absolute continuous function, indefinite integration and differentiation. (15 Hours)

3. Signed Measure: Signed measure, positive and negative sets, Hahn decomposition theorem, singular measure, Jordan decomposition, absolutely continuous measure function. (15 Hours)

References:


3. K. P. Gupta: Measure Theory, Krishna Prakashan Media (P) Ltd, 11, Shivaji Road, Meerut (U. P.), India.


Preamble: It can also be used as a supplemental text of courses in graph theory, combinatorics and related areas. It will be a valuable tool to researchers and advanced post graduate students. They can use to familiarize themselves with the subject, the research techniques and major research accomplishments in the field. The students will find many topics that can be developed into masters theses and Ph.D dissertation.

1. **Domination in Graphs:** Dominating sets, Bounds on dominating sets in terms of order, degree; Bounds in terms of order and size; Bounds in terms of degree and diameter, Bounds in terms of independent number and covering number. (20 Hours)

2. Independent sets. Irredundant sets, Total dominating sets, Connected dominating sets, Weak dominating sets, Weakly connected dominating sets, Strong dominating sets, Restrained dominating sets, Roman dominating sets. Independent, total, connected, weakly, strong, restrained roman domination numbers. (22 Hours)

3. **Graph Valued Functions:** Line graph, characterization, outer planarity, minimally non-outer planarity of line graphs and second line graphs. Blok-vertex tree of a graph, semi-total block graph and total block graph of a graph, square graph, lict graph, litact graph, total graph, middle graph and their planarity properties. (15 Hours)

4. **Crossing Numbers:** Line graph, Semitotal block graph, Total-block graph, Total graph, Lict graph and Litact graph. (07 Hours)

References:


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**Paper: HCT 4.3 Computational Numerical Methods - II**

<table>
<thead>
<tr>
<th>Teaching Hours: 4 Hrs/Week</th>
<th>Credits: 04</th>
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<td>Maximum Marks: 100 (SEE-80 + IA-20)</td>
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Preamble: The purpose of this course is to study various numerical methods for the solution of ordinary and partial differential equations. The single step methods like Runge-Kutta method for solving simultaneous and higher order ordinary differential equations, shooting method are useful for solving several problems arising in the study of real life problems. Similarly, the finite difference techniques for the solution of parabolic, hyperbolic and elliptic partial differential equations to be studied in this paper are very useful for the students in solving some of the problems arising in fluid mechanics.

1. **Numerical Solution of Ordinary Differential Equations:** Initial Value Problems- Taylor’s series method, Picard’s method (Recapitilation). Euler’s method, Runge-Kutta 4th order method, stability of 1st
order and 2nd order methods, Runge-Kutta method for simultaneous and higher order differential equations. (12 Hours)


References:


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<tr>
<th>Paper : HCT 4.4 Differential Geometry</th>
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</table>

Preamble: This syllabus is an elementary account of the geometry of curves and surfaces. It is written for students who have completed standard first course in calculus and linear algebra, and its aim is to introduce some of the main ideas of differential geometry. The traditional undergraduate course in differential geometry has changed very little in the last few decades. By contrast, geometry has been advancing very rapidly at the research level, and there is general agreement that the undergraduate course needs to be brought up to date. However, the syllabus is framed with new idea only if it really pays its way by simplifying and clarifying the exposition.

1. Directional Derivatives: Definition of Directional derivatives curves in , reparametrization of a curve, 1-Forms, differential Forms, mappings, derivative map. (14 Hours)
2. **Frame Fields**: Frame at a point, Dot and cross product of the vector fields, geometric study of curves, the Frenet formulas, arbitrary – speed curves, covariant derivatives, Frame fields, connection forms. (20 Hours)

3. **Euclidean Geometry**: Isometric of \( \mathbb{E}^1 \), the derivative map of an isometry, orientation, Euclidean geometry, convergence of curves. (15 Hours)

4. **Calculus on a Surface**: Surface in \( \mathbb{E}^3 \), patch computations differentiable functions and tangent vectors. Differential Forms on a surface, Mapping of surfaces, Topological properties of surfaces. (15 Hours)

**References:**


<table>
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<tr>
<th>Paper : SCT 4.1 Fluid Mechanics – II</th>
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1. **Fluid Equations for Newtonian Fluids**: Momentum equation, general stress state of deformable bodies, relation between stresses and rate of deformation, Stokes hypothesis, Navier-Stokes equations, energy equation. (16 Hours)

2. **Dimensional Analysis**: Reynolds number, Buckingham’s theorem, physical significance of non dimensional numbers (12 Hours)

3. **Exact Solutions of Navier - Stokes Equations**: Couette Poiseuille flows, Hagen-Poiseuille flow through a circular pipe, steady flow between co-axial circular pipes, steady flow in pipes of elliptic cross-
section, steady flow in pipes of equilateral triangular section, steady flow in pipes of rectangular sections, unsteady motion of a flat plate, flow due to an oscillating flat plate, pulsatile flow between parallel surfaces, unsteady flow of viscous incompressible, incompressible fluid between two parallel plates. (16 Hours)

4. Laminar Boundary Layer Flow: Two dimensional boundary layer equations for flow over a plane wall, boundary layer flow along a flat plate, boundary layer thickness, energy thickness, displacement thickness, momentum thickness, friction drag, momentum integral equation for the boundary layer, Van Karmans Pohlhausen method. (20 hours)

References:

<table>
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<tr>
<th>Paper : SCT4.2 Computational Fluid Dynamics</th>
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1. Fundamentals: Finite Difference Method, Programming languages such as FORTRAN and C++, Conservation Equations, Reynold’s-Averaged Navier-Stokes Equations, Stokes’s Flow, Boundary layers, Stability Equations, Classification of Conservation Equations, Boundary Conditions. (12 Hours)


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<td>Maximum Marks: 100 SEE: Project Report – 60 + Viva – Voce - 20 + IA: 20</td>
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SEE - Semester End Examination
IA – Internal Assessment