THAPAR UNIVERSITY, PATIALA

Detailed Scheme of
M.Sc. (Mathematics and Computing)

SCHOOL OF MATHEMATICS AND COMPUTER APPLICATIONS
Name of Programme: Master of Science (Mathematics and Computing)

Nature: Full time/ Part time/ Correspondence: Full Time

Duration: Two Years (4 Semesters)

Eligibility Criteria and Admission Procedure: Minimum 60% (55% for SC/ST) at graduation level with Mathematics as main subject. Admissions shall be made by merit which will be made by combining percentage of marks obtained at 10th, 12th and graduation (aggregate marks upto second year/four semesters will be considered). Graduation must be done from a recognized University.

Number of Seats: 20

Objective of the program: The objectives of the M.Sc. (Mathematics and Computing) program are to develop students with the following capabilities:

1. To provide students with a knowledge, abilities and insight in Mathematics and computational techniques so that they are able to work as mathematical professional.
2. To provide students with advanced mathematical and computational skills that prepares them to pursue higher studies and conduct research.
3. To train students to deal with the problems faced by software industry through knowledge of mathematics and scientific computational techniques.
4. To provide students with knowledge and capability in formulating and analysis of mathematical models of real life applications.
5. To increase students self-confidence in conducting research independently or within a team.

Outcome of the program: The successful completion of this program will enable the students to:

1. Demonstrate the ability to conduct research independently and pursue higher studies towards the Ph.D. degree in mathematics and computing.
2. Carry out development work as well as take up challenges in the emerging areas of Industry.
3. Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life applications.
4. Acquire deep knowledge of different mathematical and computational disciplines so that they can qualify NET/ GATE examination.
## SCHEME OF COURSES FOR M.Sc. (Mathematics and Computing)

### First Semester

<table>
<thead>
<tr>
<th>S. No</th>
<th>Course No.</th>
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Real Analysis – I

Prerequisite(s): None

Course Objectives: This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs, the course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts of limits, continuity, compactness, differentiability, and integrability, rigorously defined; Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing.

Real Number System and Set Theory: Completeness property, Archmedian property, Denseness of rationals and irrationals, Countable and uncountable, Cardinality, Zorn’s lemma, Axiom of choice.

Metric Spaces: Open and closed Sets, Interior, Closure and limit points of a set, Subspaces, Continuous functions on metric spaces, Convergence in a metric space, Complete metric spaces, Compact metric spaces, Compactness and uniform continuity, Connected metric spaces, Totally boundedness, Finite intersection property.

Sequence and Series of Functions: Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel’s and Dirichlet’s tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation, Weierstrass approximation theorem.

Riemann-Stieltje’s Integral: Definition and existence of Riemann-Stieltje’s integral, Properties, Integration and differentiation, Fundamental theorem of calculus.

Functions of Several Variables: Linear transformations, Derivatives in an open subset of $\mathbb{R}^n$, Chain rule, Partial derivatives, Inter-change of the order of differentiation, Derivatives of higher orders, Taylor’s theorem, Inverse function theorem, Implicit function theorem, Jacobians, Extremum problems with constraints, Lagrange’s multiplier method, Differentiation of integrals.

Course outcome: After the completion of this course the student will be able to
- use results and techniques involving these concepts to solve a variety of problems, including types of problems that they have not seen previously;
- know how completeness, continuity, and other notions are generalized from the real line to metric spaces
- appreciate the Contraction Principle in abstract metric space theory as a powerful tool to solve concrete problems, especially in differential equations

Recommended Books:
The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.

**Group Theory:** Groups, Subgroups, Normaliser, Oentralizer, Normal subgroups, Quotient groups, Homomorphisms, Automorphisms of groups and structure of cyclic groups, Permutation groups, Cayley’s theorem, Conjugate elements, Dlass equation, Structure theory of groups, Cauchy theorem, Sylow theory and its applications.

**Ring Theory:** Special kinds of rings, Subrings and ideals, Algebra of ideals, Homomorphisms, Quotient rings, Prime and maximal ideals, Quotient rings, Polynomial rings, Integral domain, Factorization theory in integral domains, Unique factorization domain, Principal ideal domain, Euclidean domain.

**Vector Spaces:** Vector spaces, Subspaces, Quotient spaces, Linear dependence, Basis, Dimension, Algebra of linear transformations, Algebra of matrices, Matrix representation of linear transformations, Change of basis.

**Course Outcomes:**
- The students will get a good understanding of the concepts and methods of algebra.
- They will develop abstract and critical reasoning by studying logical proofs and the axiomatic method as applied to modern algebra.

**Recommended Books:**

PMC103 Complex Analysis

Prerequisite(s): None

Course Objectives: This course is aimed to provide an introduction to the theories for functions of a complex variable. It begins with the exploration of the algebraic, geometric and topological structures of the complex number field. The concepts of analyticity, Cauchy-Riemann relations and harmonic functions are then introduced. Students will be equipped with the understanding of the fundamental concepts of complex variable theory. In particular, students will acquire the skill of contour integration to evaluate complicated real integrals via residue calculus.


Elementary Functions: Exponential function, Trigonometric functions, Logarithmic function and its branches, Inverse trigonometric and hyperbolic functions.


Conformal Mapping: Elementary conformal maps, Bilinear transformation, Schwarz-Christoffel transformation, Analytic continuation, Method of analytic continuation by power series, Natural boundaries.

Course Outcomes: After the completion of this course the student will be able to
- Represent complex numbers algebraically and geometrically,
- Define and analyze limits and continuity for complex functions as well as consequences of continuity,
- Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra,
- Analyze sequences and series of analytic functions and types of convergence,
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula, and
- Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Recommended Books:

Course Objective: The aim of this course is to provide adequate knowledge of fundamentals of computer along with problem solving techniques using C programming. This course provides the knowledge of writing modular, efficient and readable C programs. Students also learn the utilization of arrays, structures, functions, pointers and implement these concepts in memory management. This course also teaches the use of functions and file systems.

Computer’s General Concepts: Historical overview, Technological advancement in computers including categories and usage of computers.

Hardware and Software: CPU, Primary memory, Secondary storage devices, Input devices, Output devices, Significance of software in computer system, Categories of software – System software, Application software, Compiler, Interpreter, Utility program, Binary arithmetic for integer and fractional numbers, Operating System and its significance.

C Programming: Introduction to algorithm, Flow charts, Problem solving methods, Need of programming languages. C character set, Identifiers and keywords, Data types, Declaration, Statement and symbolic constants, Input-output statements, Preprocessor commands, Operators, expressions and library functions, decision making and loop control statements, Functions, Storage Classes, Arrays, Strings, Pointers, Structure and union, File handling.

Laboratory Work: Laboratory experiments will be set in consonance with the materials covered in theory.

Course Outcomes: After completion of this course, the students would be able to

- Know the various hardware and software used in computer science.
- Understand C programming development environment, compiling, debugging, linking and executing a program using the development environment
- Understand and apply the in-built functions and customized functions for solving the problems.
- Understand and able to use arrays, pointers, memory allocation techniques and use of files for dealing with variety of problems.
- Analysing the complexity of problems, modularize the problems into small modules and then convert them into programs.

Recommended Books:

PMC105 Discrete Mathematical Structures

L T P Cr
3 1 0 3.5

Prerequisite(s): None

Course Objectives: Prepare students to develop mathematical foundations to understand and create mathematical arguments, require in learning many mathematics and computer sciences courses. To motivate students how to solve practical problems using discrete mathematics

Mathematical Logic: Statement and notations, Connectives, Statement formulas and truth table, Conditional and bi-conditional statements, Tautology and contradiction, Equivalence of formulas, Tautological implications.


Relation: Definition and properties of binary relations, Equivalence relations, Compatibility relation, Composition of binary relations, Composition of binary relations and transitive closure, Partial ordering and partial ordered set (representation and associated terminology).

Function: Injection, Surjection and bijection, Composition of function, Pigeonhole principle, Hashing function, Complexity of function and binary operations.

Recursion and Recurrence Relation: Primitive recursive function, Polynomials and their recursion, Iteration, Sequence and discrete functions, Recurrence relations, Generating function.

Lattice and Boolean Algebra: Lattice and algebraic system, Basic properties of algebraic systems, Special types of lattices, Distributed, Complemented lattices, Boolean algebra, Boolean expressions, Normal form of boolean expressions, Boolean function, Basic circuits and theorems, Logical gates and relations of boolean function.

Course Outcomes: The successful completion of this course will enable the students to:
- Construct mathematical arguments using logical connectives and quantifiers.
- Validate the correctness of an argument using statement and predicate calculus.
- Understand how graphs and trees are used as tools and mathematical models in the study of networks.
- Learn how to work with some of the discrete structures which include sets, relations, functions, graphs and trees.

Recommended Books:

PMC106 Differential Equations

L T P Cr
3 1 0 3.5

Prerequisite(s): None

Course Objectives: The theories of modern physics, generally involve a mathematical model, as far as possible, it is a set of differential equations. In recent years, the differential equations become the most important tool to study various applied sciences as well as engineering phenomenon. This is due to the fact that most of the scientific and engineering problems contain the rate of change of one or more quantities with respect to one or more independent variables (generally these are time and space variables) and any problem with rate of change can be easily modeled in terms of differential equation. We can study differential equations in three main ways: Analytic methods for an exact solution of a differential equation, Numerical techniques, which provide approximate solutions, generally using a computer, Qualitative study of differential equations to discuss general properties of solution without exact solutions. In this course, we will mainly emphasize on analytic methods. Some qualitative study will also be discussed, but numerical techniques will be left for other courses.

Introduction to ODE’s: Review of fundamentals of ODEs, Applications of differential equations to vibrations of mass in a spring, Free undamped motion, Free damped motion, Forced motion, Resonance phenomenon and electric circuit problems, Existence and uniqueness theorems.


Partial Differential Equations: First-order linear and quasi-linear PDE’s, method of lagrange’s, Cauchy problem, Complete integrals of non-linear equations of first order, Four standard forms, Charpits’ method, Linear equations with constant coefficients, Classification of PDE, Characteristics, Solution of hyperbolic, Parabolic and elliptic equations, Dirichlet and Neumann problems, Green’s functions for elliptic, Parabolic and hyperbolic equations.

Course Outcomes: By the end of this course, a student will able to:

- Formulate the differential equations model for vibrations of mass on a spring with free undamped motion, free damped motion, forced motion, Resonance phenomenon and model for electric circuit problems.
- Obtain power series solutions of several important classes of ordinary differential equations including Bessel's, Legendre, Hermite, Gauss’s hypergeometric and Chebyshev’s differential equations. Also able to derive the generating functions and recurrence relations and interpret their qualitative behaviour.
- Discuss the stability of linear and nonlinear systems, nonlinear conservative systems by eigen value methods as well as Liapunov’s direct method.
- Solve the first-order linear and Quasi-linear PDE’s with the aid of Lagrange’s method and non-linear PDEs of first order with Charpits’ method.
- Derive solutions of linear PDEs of second and higher order with constant coefficients.
- Use the method of separation of variables and Green functions in order to solve some basic hyperbolic, parabolic and elliptic partial differential equations.
Recommended Books:

Prerequisite(s): None

Course Objectives: This course provides the essential foundations of important aspect of mathematical analysis. Measure theory and theory of the integral have numerous applications in other branches of pure and applied mathematics, for example in the theory of (partial) differential equations, functional analysis and fractal geometry. The objective of this course is to give mathematical foundation to probability theory and statistics, and on the real line it gives a natural extension of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration.

Lebesgue Measure: Introduction, Outer measure, Lebesgue measure measurable sets, Properties of measurable sets, Borel sets and their measurability, Non-measurable sets.

Measurable Functions: Definition and properties of measurable functions, Step functions, Characteristic functions, Simple functions Littlewood’s three principles,

Lebesgue Integral: Lebesgue integral of bounded function, Integration of non-negative functions, General lebesgue integrals, Integration of series, Comparison of Riemann and Lebesgue integrals.

Differentiation and Integration: Differentiation of monotone functions, Functions of bounded variation, Lebesgue differentiation theorem, Differentiation of an integral, Absolute Continuity.


Course Outcomes: After completing this course, the student will
- understand how Lebesgue measure on R is defined,
- understand how measures may be used to construct integrals,
- know the basic convergence theorems for the Lebesgue integral,
- understand the relation between series and the Hilbert space of square integrable functions

Recommended Books
PMC202 Operation Research

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Prerequisite(s): None

Course Objectives: Operations research helps in solving problems in different environments that needs decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions making; model formulation and applications that are used in solving business decision problems.


Integer Programming: Gomory’s cutting plane algorithm, Branch and bound technique, For pure and mixed integer linear programming problem.


Game Theory: Two person zero-sum game, Game with mixed strategies, Dominance property, Graphical method and solution by linear programming.

Inventory Problems: Deterministic models.

Network Analysis: Maximum flow problem, Project management with PERT-CPM.

Nonlinear Programming: Concept of convexity and concavity, Maxima and minima of convex functions, Single and multivariate unconstrained problems, Constrained programming problems, Kuhn-Tucker conditions for constrained programming problems, Quadratic programming. Separable programming.

Laboratory Work: Laboratory experiments will be set in consonance with the materials covered in theory.

Course Outcomes:

- The students will be able to get awareness about the real world problems, their understanding and ability to formulate mathematical models of these problems. For example: Finance, Budgeting, Investment, Agriculturist, Transportation, Cable network, Traveling salesman and many more such problems.
- Students will be able to understand the major limitations and capabilities of deterministic operations research modeling as applied to problems in industry or government.
- The student will learn to handle and solve and analyzing problems using linear programming and other mathematical programming algorithms.
- The students will also learn how to deal with real world problems of Network analysis, Project Management, for their optimal solutions; for example, they
understand how much optimum cable wire is required to give cable connection to some buildings connected by a network.

- The students will also be able to learn different techniques to solve Non-Linear Programming Problems.
- They can also use search techniques methods, which is based on iterative methods, to find optimal solutions of Non-Linear Programming Problems. Also students understand multistage decision problems.

**Recommended Books:**

Prerequisite(s): None

Course Objectives: The course is intended as a basic course in numerical analysis. The objective of the course is to familiarize the students about different numerical techniques e.g. solving algebraic and transcendental equations, large linear system of equations, differential equations, approximating functions by polynomials up to a given desired accuracy, finding approximate value of definite integrals of functions etc. The course also throws light on the convergence analysis of these techniques and explains different types of errors which gets involved and propagates during numerical computations.


Linear Systems and Eigen-Values: Gauss-elimination method (using pivoting strategies), Triangularisation method, Jacobi’s and Gauss-Seidel iterative methods and their convergence Rayleigh’s power, Jacobi’s method, Given’s method for eigen-values and eigen-vectors.


Numerical Integration: Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature with error analysis.


Laboratory Work: Laboratory experiments will be set in consonance with the materials covered in theory.

Course Outcomes: Upon completion of the course, the students should be able to
- Solve the large scale of linear system of equations.
- Handle even very complicated functions by approximating the functions by polynomials up to desired accuracy.
- Find approximate value of definite integrals of functions
- Analyze convergence and error estimates of various numerical techniques
- Solve differential equations governing real life phenomenon arising in various fields of science and engineering.
Recommended Books

Prerequisite(s): None

Course Objectives: This course shall help the students in understanding how to analyze a given algorithm. This course will also help them in making the choice of data structures and methods to design algorithms that affect the performance of programs. They will also learn to solve problems using data structures such as linear lists, stacks, queues, etc. and shall be writing programs for these structures.

Introduction: Need and definition of data structures, Asymptotic notations, Recursion and recursive functions.

Fundamental Data Structures: Arrays, Stacks, Queues, Linked lists and trees.

Searching and Sorting: Linear search, Binary search, Insertion-sort, Bubble-sort, Selection-sort, Merge sort, Heap sort, Priority queue, Quick sort, Sorting in linear time, Hash tables, Binary search tree, Balanced trees (red-black tree, AVL tree).

Graphs: Elementary graph algorithms, Minimum spanning tree, Shortest path algorithms.

Algorithm Design Techniques: Divide and conquer, Dynamic programming, Greedy algorithm, Amortized analysis.

Laboratory work: Laboratory exercises will be set in consonance with the material covered in lectures. This will include assignments in a programming language like C and C++ in GNU Linux environment.

Course Outcomes: After the completion of this course the student will be able to:
- Analyze a given algorithm for its complexity.
- Appreciate the role of data structures in different implementations.
- Implement algorithm design techniques to different problems

Recommended Books:

PMC205 Data Base Management Systems

Prerequisite(s): None

**Course Objectives:** The major objective of this course is to provide a strong formal foundation in database concepts, technology and to give an introduction to systematic database design approaches covering conceptual design, logical design and an overview of physical design. This course will also introduce the concepts of transactions and transaction processing to present the issues and techniques relating to concurrency and recovery. The overriding concern, is present the concepts and techniques by SQL engine and PL/SQL programming.

**Introduction:** Basic concepts, Database and database users, Characteristics of the database, Database systems concepts and architecture, Data models, Schemas and instances, DBMS architecture and data independence, Database languages and interfaces.

**Data Modeling:** ER model concepts, Notation for ER diagram, Mapping constraints, Concepts of primary key, Candidate key, Foreign key and super key.

**Relational Model, Languages and Systems:** Relational data model and relational algebra, Relational model concepts, Relational model constraints, Relational calculus: Tuple and domain calculus.

**SQL:** SQL data types. Data definition in SQL, View, Queries and sub queries in SQL, Specifying constraints and indexes in SQL, Cursors, Triggers, Procedures and packages in PL/SQL.

**Relational Data Base Design:** Function Dependencies and normalization for relational databases, Normal forms: INF, 2NF, 3NF, and BCNF, Loss less join and dependency preserving decomposition.

**Concurrency Control and Recovery Techniques:** Concurrency control techniques, Locking techniques, Time stamping protocols for concurrency control, Multiple granularity of data items, Recovery techniques, Database backup and recovery.

**Distributed Database Systems:** Introduction to Distributed DBMS, Overview of client-server architecture.

**Laboratory Work:** Laboratory exercises should include defining schema for applications, creation of a database, writing SQL and PL/SQL queries for database operations.

**Course Outcomes:** After the completion of this course the student will be able to

- Understand, appreciate and effectively explain the underlying concepts of database technologies.
- Design and implement a database schema for a given problem-domain.
- Populate and query a database using SQL DML/DDL commands.
- Programming PL/SQL including stored procedures, stored functions, cursors, packages.
**Recommended Books:**

MC206 Computer Organization and Operating Systems

Prerequisite(s): None

Course Objectives: The course aims to shape the attitudes of learners regarding the field of computer organization as well as operating system. Specifically, the course aim to i) Have the insight of computer organizations and the working of operating systems ii) Instill the belief that computer organization as well as operating is important for IT professional.

Introduction: Computer organization, Operating system, Types of operating systems, Register transfer language, Overview of data representation in computer, Instruction, Instruction codes, Instruction types, Instruction set completeness, Instruction cycle, Execution cycle, Addressing modes, Control unit: Micro programmed control Vs hardwired control, RISC Vs CISC.

Input Output Organization: Input and output interface, Asynchronous data transfer, Modes of transfer, DMA, I/O interrupts, Channels.

Pipeline: Parallel processing, Arithmetic pipeline, Instruction pipeline


Memory Management: Memory hierarchy, Associative memory, Demand paging-virtual memory and Segmentation, File Management: File system structure, Allocation methods, Secondary storage management - disk scheduling.

Laboratory Work: Implementation of CPU scheduling algorithms, process management, memory management and file management functions of Linux/Unix operating systems.

Course Outcomes: After the completion of this course the student will be able to
- Understand, appreciate and effectively explain the underlying concepts of computer organization.
- have the idea about instruction set, instruction cycle, RISC as well as CISC.
- know the process management, scheduling and deadlock.
- Understand the memory management, and file system.

Recommended Books:

2. Galvin and Silverscatz, Operating systems concepts, Addison Wesley (2012).
PMC301 Mathematical Methods

Prerequisite(s): None

Course Objectives: This course is intended to prepare the student with mathematical tools and techniques that are required in advanced courses offered in the applied mathematics and engineering programs. The objective of this course is to enable students to apply transforms and variation problem technique for solving differential equations and extremum problems.

Laplace Transform: Review of Laplace transform, Applications of Laplace transform in initial and boundary value problems, Heat equation, Wave equation, Laplace equation.

Fourier Series and Transforms: Definition, Properties, Fourier integral theorem, Convolution theorem and Inversion theorem, Discrete fourier transforms (DFT), Relationship of FT and fast fourier transforms (FFT), Linearity, Symmetry, Time and frequency shifting, Convolution and correlation of DFT. Applications of FT to heat conduction, Vibrations and potential problems, Z-transform.


Integral Equations: Linear integral equations of the first and second kind of fredholm and volterra type, Conversion of linear ordinary differential equations into integral equations, Solutions by successive substitution and successive approximation, Neumann series and resolvent kernel methods.

Calculus of Variations: The extrema of functionals, The variation of a functional and its properties, Euler equations in one and several independent variables, Field of extremals, Sufficient conditions for the extremum of a functional conditional extremum, Moving boundary value problems, Initial value problems, Ritz method.

Course Outcomes: After the completion of this course the student will be able to:

- Use mathematical methods and theories on various mathematical and physical problems;
- Demonstrate accurate and efficient use of Fourier series and integral transform techniques;
- Apply Fourier series and integral transform techniques applied to diverse situations in physics, engineering and other mathematical contexts;
- Formulate and solve problems in the calculus of variations

Recommended Books:

Course Objectives: The course aims to shape the attitudes of learners regarding the field of statistics. Specifically, the course aim to i) Motivate in students an intrinsic interest in statistical thinking. ii) Instill the belief that statistics is important for scientific research.

Introduction: Definition of probability through different approaches.

Random Variables: Probability distribution of a random variable, Distribution function, Discrete and continuous random variables, Functions of a random variable.

Mathematical Expectation: Moments, Moment generating functions, Characteristic function.

Study of Special Distributions: Binomial, Poisson, Negative binomial, Geometric, Rectangular, Exponential, Normal, Gamma, Log-normal distributions.

Bi-Variate Probability Distribution: Marginal and conditional distributions, Bi-variate normal distribution.

Limit Theorems: Modes of convergence and their interrelationships; Law of large numbers, Central limit theorem.

Correlation and Regression: Regression between two variables, Karl-Pearson correlation coefficient and rank correlation. Multiple regression, Partial and multiple correlation (three variables case only).

Random Sampling: Sampling distributions chi-square, T and F distributions.

Point Estimation: Probabilities of point estimates, Method of maximum likelihood.

Testing of Hypothesis: Fundamental notions, Neyman-Pearson lemma (without proof), Important tests based on normal, Chi-square, T and F distributions.

Interval Estimation: Confidence interval for mean and variance.

Laboratory Work: Lab work will be based on the programming in C/ C++ language of various statistical techniques. Various statistical aspects are covered in SPSS also.

Course Outcomes: After the completion of this course the student will be able to

- To create, simulate, and analyze elementary probability models.
- To explain the limitations of the statistical inferences.
- Apply fundamental concepts in exploratory data analysis.
Recommended Books:

Prerequisite(s): None

Course Objectives: The course has been intended to impart knowledge in the domain of topology, data communication, protocols and data propagation issues in computer networks. The contents are descriptive to enforce knowledge of working of seven layers of network model, path finding issues, security and other communication paradigm.


Data Link Layer: Design issues, Framing, Error control, Flow control, Error correcting codes, Error detecting codes, Sliding Windows protocols, HDLC, PPP, Channel allocation problem, Multiple access protocols, Ethernet.


Transport Layer: Services provided to the upper layer, Addressing, UDP, TCP, Connection establishment, connection release, Flow control and buffering, Multiplexing, TCP congestion control, TCP timer management, Introduction to SCTP.

Application Layer: Introduction to Domain name system, E-mail, File transfer protocol, HTTP, HTTPS, World Wide Web.

Laboratory Work: The lab work will be based on network installation using Windows server and Linux server, implementation of the different application layer protocols on these server, configuration of network devices like switches, routers and implementation of the protocols on these devices. Socket programming using different types of sockets.

Course Outcomes: After the completion of this course the student will be able to
- Understand network topologies, protocols and communication standards
- Know the working of seven layer network models, TCP/IP, OSI etc.
- Appreciate data binding, packetizing, transmission issues etc.
- Understand construction and working of a network
- Compare and contrast working of different network protocols

Recommended Books:

Prerequisite(s): None

Course objectives: This course is intended to provide a treatment of basic knowledge in mechanics used in deriving a range of important results and problems related to rigid bodies. The objective is to provide the student the classical mechanics approach to solve a mechanical problem.

Dynamics of a Particle: Tangential and normal accelerations, Simple harmonic motion, Oscillatory motion projectile motion, Central forces, Apses and apsidal distances, Stability of orbits, Kepler’s laws of planetary motion, Disturbed orbits, Simple pendulum, Motion in a resisting medium, Motion of a pendulum in a resisting medium.

Linear and Angular Momentum: Rate of change of angular momentum for a system of particles, Moving origin, Impulsive forces, Moments and products of inertia of a rigid body, Momental ellipsoid, Equimoment system, Principal axes, Coplanar distribution, General equations of motion.

Motion About a Fixed Axis: Compound pendulum, Centre of percussion, Motion in two dimensions, Euler's dynamical equations and simple stability considerations, Finite forces, Kinetic energy in two dimensions, Moment of momentum in two dimensions.

Classical Mechanics: Constrained motion, D’Alemberts principle, Variational Principle, Lagrange’s equations of motion, Generalised coordinates, cyclic coordinates, Hamilton’s principles, Principles of least action, Hamilton’s equation of motion, Lagendre transformation, Phase, Space, State space examples, Canonical transformations, Contact transformation, Lagrange’s and poisson brackets integral in variances, Hamilton-Jacobi Poisson equations.

Course outcomes: After the completion of this course the student will be able to
- demonstrate a deep understanding of the laws of motion governing the behaviour of rigid bodies.
- use the Lagrangian and Hamiltonian approach of solving a problem in addition to Newtonian approach.
- study higher courses like theory of elasticity, fluid mechanics etc.

Recommended Books:

PHU- PROFESSIONAL COMMUNICATION

Prerequisite(s): None

Course Objectives: To provide the students with the essential skills required for effective communication and a comprehensive view of business communication and its role in the corporate environment.

Essentials of Communication: Meaning, Definition, process, feedback, emergence of communication as a key concept in the corporate and global world, impact of technological advancements on communication.


Methods and Modes of Communication: Verbal and nonverbal, Verbal Communication: Characteristics of verbal communication, Non-verbal Communication: Characteristics of non-verbal communication, kinesics, proxemics and chronemics.

Barriers to Communication: Physical, semantic, language, socio-cultural, psychological barriers, Ways to overcome these barriers.

Listening: Importance of listening skills, cultivating good listening skills.

Written Communication: Business letters, memos, minutes of meeting, notices, e-mails, agendas and circulars.


Presentations: Principles of effective presentation, power-point presentation, video and satellite conferencing.

Interviews and Group Activities: Personal interviews, group discussion and panel discussion

Creative writing: Paragraph and Essay writing, Book reviews, Movie Reviews, Editorials and articles.

Paper writing: Styles of paper writing: Short Communication, Review papers and Research papers, Referencing styles: MLA, Chicago Style and APA.

Course Outcomes:

- Understand and demonstrate the use proper writing techniques relevant to the present day technological demands, including anticipating audience reaction,
- Write effective and concise letters and memos,
- Prepare informal and formal reports,
• Proofread and edit copies of business correspondence
• Develop interpersonal skills that contribute to effective personal, social and professional relationships

Recommended Books:

MC401 Functional Analysis

Prerequisite(s): None

Course Objectives: Many advanced mathematical disciplines, e.g., Fourier analysis, numerical analysis, the calculus of variations, the theory of differential and integral operators, have a common foundation incorporating among others fundamental notions and abstractions associated with linear spaces of functions (functional analysis). It is the purpose of this course to provide students with basic concepts from functional analysis to facilitate the study of advanced mathematical structures arising in the natural sciences and the engineering sciences and to grasp the newest technical and mathematical literature.

Normed Linear Spaces: Normed linear space, Banach space and examples ($l_1$, $l_p$, $l_\infty$). Quotient spaces, Equivalent norms, Bounded linear transformation, Normed linear spaces of bounded linear transformations, Hahn-Banach theorem and its applications, Riesz-Representation theorem, Uniform boundedness principle, Open mapping theorem, Projection on a banach space, Closed graph theorem, Dual spaces with examples.

Hilbert Spaces: Inner product spaces, Hilbert spaces, Orthogonality, Orthonormal sets, Bessel’s inequality, Parseval’s theorem, Orthogonal complement and projection theorem, Riesz-Representation theorem.

Operators: Adjoint operators, Self-adjoint operators, Positive operators, Normal and Unitary operators, Projection.

Course Outcomes:

1. The students will be able to understand the need to introduce Functional Analysis with special emphasis on Hilbert- and Banach Space Theory.
2. The students will be able to distinguish between finite and infinite dimensional mathematical problems.
3. They will recognize and exploit bounded/ unbounded linear operator in mathematical contexts.
4. Will be able to understand theoretical parts of the natural and engineering sciences in context with functional analysis.
5. Exploit linear operators in the formulation of differential and integral equations.

Recommended Books:

Prerequisite(s): None

Course Objectives: The main objective of this course is to encourage students to develop a working knowledge of the central ideas of Linear Algebra like linear transformations, eigen values, eigen vectors, canonical forms and Field Theory like field extensions, splitting field and Galois theory.

Canonical Forms: Linear transformations and their characteristic roots and vectors, Minimal polynomial of a linear transformation, Geometric and algebraic multiplicity, Singular and non-singular transformations, Minimal polynomial of a vector relative to a linear transformation, Triangular form, Jordan canonical form.

Field Theory: Characteristic of a field, Subfield and prime field, Extension of fields, Finite and infinite extensions, Algebraic element, Minimal polynomial of an algebraic element, Algebraic and transcendental extensions, Splitting fields, Multiple roots, Separable and inseparable extensions, Finite fields, Galois theory, Monomorphisms and their linear independence, Normal extensions, Fundamental theorem of Galois theory.

Algebraic Coding Theory: Overview of coding theory, Error detecting and correcting codes, Matrix codes, Group codes.

Course Outcomes:
- The students will get a good understanding of the deeper concepts of linear algebra and field theory.
- They will advance their knowledge to pre-doctoral level.

Recommended books:
PMC311 Computer Graphics

Prerequisite(s): None

Course Objectives: The course develops student’s knowledge and understanding in the fundamental principles of computer graphics, hardware system architecture for computer graphics, computer graphic algorithms such as geometric representation, scan conversion; and 2D and 3D objects’ viewing and transformation. The student will be able to understand the basic mathematical concepts related to computer graphics including linear algebra and geometry, graphics pipeline, frame buffers, and graphic accelerators/co-processors.

Introduction: Applications and importance of computer graphics in different areas; Graphics input devices, Output devices display devices-random scan and raster scan displays. Display of colors: Lookup tables, Display of gray shades, Half toning.

Graphics Hardware: Video controller, Graphics controller, Raster scan display processor.

Scan Conversion: Scan converting lines, Rectangles, Circles, Ellipses, Arcs and sectors. DDA algorithm, Bresenham Algorithm, Midpoint algorithms for line and circle.

Filling Polygons: Boundary fill, Flood fill, Scan line polygon fill algorithm.

Transformations: 2D transformations, 3D transformations, Homogeneous coordinates and matrix representation, translation, scaling, rotation. Composition of 2D transformations and 3D transformations.


Mathematics of Projection: Perspective projection, Parallel projection.


Illumination And Shading: Illumination models, shading models for polygons, shadows, transparency.

Laboratory Work: Laboratory experiments will be set in consonance with the materials covered in theory.

Course Outcomes: Upon successful completion of this course, the student will be able to:

- understand the basic mathematical models and algorithms related to geometric representation scan conversion and object viewing and transformation;
- understand and recognize essential concepts, principles, theories, current and future development for computer graphics disciplines.
- develop skill in image rendering using computer graphics technology;
- develop good understanding of various graphics algorithms and the trend of their use in various real-life systems

**Recommended Books:**

Prerequisite(s): None

Course Objectives:
The main objective of this course is to define and highlight the importance of object oriented programming. The students will see how to use concepts of object oriented programming in real-life using C++ programming language. The students will learn potential C++ features like overloading, type conversions, inheritance.

Introduction: Object oriented vs. procedural programming, Object oriented programming Features and benefits, Characteristics of the object oriented approach, Identifying object classes, Class identification.

Classes and Objects: Defined member functions, Members access control, Use of scope resolution operator, Making functions inline, Nesting of member functions, Private member functions, Memory allocation for objects, Static data members, Static member functions, Array of objects, Objects as function arguments, Friend functions and friend classes, Returning objects, const member functions.

Constructors and Destructors: Types of constructors- default, parameterized and copy constructors, Dynamic constructors, Multiple constructors in a class. Destructors, Rules for constructors and destructors, Dynamic initialization of objects, new and delete operators.

Operator Overloading and Type Conversions: Overloading unary, binary operators, Operator overloading using friend functions, Rules for overloading operators, Type conversions- Basic to class type, Class to basic type, One class to another class type.

Inheritance: General concepts of Inheritance, Types of derivation-public, private, protected, Types of inheritance: Single, Multilevel, Multiple and Hybrid inheritance, Types of base classes: Direct, indirect, virtual and abstract, Constructors in derived classes, Containership, Polymorphism with pointers, Pointer to objects, This pointer, Pointers to derived classes, Virtual functions, Pure virtual functions.

Files and Streams: Streams, Stream classes for console operations, Unformatted I/O operations, Formatted console I/O operations, Managing output with manipulators, File streams, Opening, Reading, Writing to file. File pointers and their manipulators.

Templates and Exception Handling: Class templates and function templates, Overloading of template functions, Basics of exception handling, Exception handling mechanisms.

Laboratory Work: Laboratory experiments will be set in context with the materials covered in theory.

Course Outcomes:
- Students will learn the fundamentals of object oriented programming using C++ programming language.
- The students will learn how OOP concepts like data abstraction, information hiding and code reusability are managed efficiently with C++.
- The C++ is potential programming language for students and programmers who are stepping in software industries and the world of information technology.
Recommended Books:

Course Objectives: The objective of the course is to introduce students with the fundamental concepts in graph Theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.

Preliminaries: Graph, sub-graph and simple graphs, graph isomorphism, matrix representations, operation on graphs, degrees, paths and connection, cycles, directed graphs, directed paths, directed cycles, The shortest path algorithms, Sperner’s lemma, chordal graph, A job sequencing problems, Designing an efficient computer drum, Making a road system one-way, Ranking the participants in a tournament.


Colorings: Edge chromatic number, Coloring of Chordal graph, Class-1 graphs, Class-2 graphs, Vizing’s theorem, Brook’s theorem, Hajos’s conjecture, Chromatic polynomials, Girith and Chromatic number. The time tabling problems, storage problem.

Laboratory work: The laboratory work shall be based upon the implementation of graph theory concepts like paths, circuits, shortest path problems, tree, Euler tour, Hamiltonian cycles, Chinese postman problem, the traveling salesman problem, Matching in Bipartite graphs, coloring of graphs.

Course Outcomes: Upon completion of the course, students should possess the following skills:
- Understand the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices.
- Understand the properties of trees and able to find a minimal spanning tree for a given weighted graph.
- Understand Eulerian and Hamiltonian graphs.
- Apply shortest path algorithm to solve Chinese Postman Problem .
- Apply the knowledge of graphs to solve the real life problem.

Recommended Books:
5. Deo, N., Graph Theory with Application to Engineering with Computer Science, PHI (2004)
Prerequisite(s): None

Course objectives: This course shall help students in understanding the role of neural networks in artificial intelligence and machine learning. Students shall get knowledge on different learning paradigms for neural networks and also on different neural network models.

Introduction: Biological Analogy, Architecture classification, Neural models, Learning paradigm and rule, single unit mapping and the perception.


Recurrent Networks – Symmetric Hopfield networks and associative memory, Boltzmann machine, Adaptive resonance networks

Other Networks: PCA, SOM, LVQ, Hopfield networks, Associative memories, RBF networks, Applications of artificial neural networks to function Approximation, Regression, Classification, Blind source separation, Time series and forecasting.

Laboratory Work: The lab work will be based on the implementations of different neural networks strategies using C/C++ (or on MATLAB/MATHEMATICA) on various case studies.

Course outcomes: After the completion of this course the student will be able to:
- Appreciate the role of neural networks in machine learning process.
- Learn the use of artificial neural networks in real life applications.
- Implement different artificial neural network models.

Recommended Books:
Prerequisite(s): None

Course Objectives: The objective of this course is to cover the basic theory and algorithms that are widely used in digital image processing, expose students to current technologies and issues that are specific to image processing systems and develop critical thinking about shortcomings of the state of the art in image processing.

Introduction and Digital Image Fundamentals: Digital image representation, Fundamental steps in image processing, Elements of digital image processing systems, Sampling and quantization, Neighbors of a pixel, Adjacency, Connectivity, Regions and boundaries, Distance measures, Image operations on a pixels basis, Linear and non linear operations.


Image Enhancement in Frequency domain: 1-D and 2-D Fourier Transform and their Inverse, Filtering, Smoothing and sharpening domain filters, Homomorphic filtering.

Image Restoration: Degradation model, Noise models, Restoration in the presence of noise only spatial filtering, Periodic noise reduction by frequency domain filtering, Estimating degradation function.

Color Image Processing: Color models, Pseudocolor image processing, Color transforms, Smoothing and sharpening, Color segmentation, Noise in color images, Color image compression.


Morphological Image Processing: Dilation and erosion, Basic morphological algorithms, Extension to gray scale images.

Image Segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region oriented Segmentation, motion based Segmentation.

Representation and Description: Representation schemes, Boundary description, Regional descriptors, Morphology.

Object Recognition: Patterns and pattern classes, Decision theoretic methods, Structural methods.

Laboratory work: The programs on image enhancement, image zooming, image cropping, image restoration, image compression, image segmentation will be implemented in MATLAB/Mathematica.

Course Outcomes: After studying this course, student will be able to
- Understand the basic theory and algorithms that are widely used in digital image processing
- Understand the current technologies and issues that are specific to image processing systems.
- Develop image processing algorithms and their testing.
- Develop critical thinking about shortcomings of the state of the art in image processing.
Recommended Books:

PMC316 Software Engineering

Prerequisite(s): None

Course Objectives: In this course, students will gain a broad understanding of the discipline of software engineering and its application to the development and management of software systems. The course will help students to learn the knowledge of basic SW engineering methods and practices, and their appropriate application, to understand software process models, processes of requirements analysis and role of project management, thorough software design concepts, tools and techniques for software construction and maintenance. Students shall be able learn various techniques, metrics and strategies for testing software projects. To learn and apply standards, CASE tools and techniques

Generic View of Software Engineering: Process models, Software requirements, Fundamentals, Requirements process, Requirements elicitation, Requirements analysis, Requirements specification, Requirements validation.

Software Project Management: Managing people, Process, Project, Software measurement, Estimation, Software risk and management, Software quality management.

Software Design: Software design fundamentals, Key issues in software design, Software structure and architecture, Software design quality analysis and evaluation, Software design notations, Software design strategies and methods

Software Construction and Maintenance: Software construction fundamentals, Managing construction, Practical considerations, Software maintenance fundamentals, Key issues, Maintenance process, Techniques for software maintenance.

Software Configuration Management: SCM process, Organizational context for SCM, Constraints and guidance for SCM process, Planning for SCM, Software configuration identification, Identifying items to be controlled, Software configuration control, Software configuration Status accounting, Software configuration auditing, Software release management and delivery


Software Engineering Tools and Methods: Software requirements tools, Software design tools, Software construction tools, Software maintenance tools, Software configuration management tools, Software engineering process tools, CASE environments, Miscellaneous tools.

Laboratory Work: Laboratory exercises to implement various stages of software development using Rational suite/MS Project.

Course Outcomes- Students successfully completing this course should be able to:

- Understand software process models and apply methods for Design and Development of software projects.
- Understand requirements analysis for software engineering problems.
- Learn basic role of project management in Software Engineering.
- Understand thorough software design concepts, different software architectural styles and object oriented analysis and design using UML.
- Learn various fundamentals, tools and techniques for software construction and maintenance.
- Appreciate various techniques, metrics and strategies for Testing software projects.
- Have an exposure to CASE tools and modeling tools such as Rational Rose.
Recommended Books:

PMC317 Design and Analysis of Algorithms

Prerequisite(s): None

Course Objectives: The aim of this course is to introduce the concepts of algorithm analysis using time complexity. This course also provides the knowledge of algorithm design methodologies.

Introduction: Algorithm definition, Analyzing algorithms, Order arithmetic, Time and space complexity, Models of computation, Growth of functions, Summations, Recurrences: substitution, iteration, the master theorem, Review of Data Structures: stacks, queues, trees, heaps, hashing, sets and graphs.

Divide and Conquer Technique: General method, Maximum-subarray problem, Strassen’s algorithm for matrix multiplication.


Dynamic Programming: Use of table instead of recursion, Rod cutting problem, Longest common subsequence problem, 0/1 knapsack problem, Optimal binary search tree problem.

Backtracking: 8 queens problem, sum of subsets, graph coloring, Knapsack problem.


Laboratory Work: Problems based upon the topics given in the syllabus should be covered in the lab.

Course Outcomes:
- After going through this course, a student shall be able to appreciate the requirements of algorithm analysis.
- One shall understand the concepts behind divide and conquer; greedy technique, backtracking and dynamic programming after going through this course.
- One will be able to understand the concept behind NP-completeness.
- A student will also have hands on experience in implementing these strategies on machine.

Recommended Books:
PMC318 Wavelet and Applications

Prerequisite(s): None

Course Objectives: The objective of this course is to cover the basic theory of wavelets, multiresolution analysis, construction of scaling functions, bases, frames and their applications in various scientific problems.

Different Ways of Constructing Wavelets: Orthonormal bases generated by a single function, The Balian-low theorem, Smooth projections on L2(R), Local sine and cosine bases and the construction of some wavelets, The unitary folding operators and the smooth projections.

Multiresolution Analysis: Multiresolution analysis and construction of wavelets, Construction of compactly supported wavelets and estimates for its smoothness, Band limited wavelets, Orthonormality, Completeness, First and second generation wavelet transform, Frames.

Characterizations in the Theory of Wavelets: Basic equations and some of its applications, Characterizations of MRA wavelets, Characterization of Lemarie-Meyer wavelets and some other characterizations, Franklin wavelets and spline wavelets on the real line, Orthonormal bases of piecewise linear continuous functions for L2(T), Orthonormal bases of periodization of wavelets defined on the real line.

Wavelets in Signal and Image Processing: Signals, Filters, Coding signals, Filters banks, Image analysis, Image compression, Edge detection.

Laboratory Work: Analysis of different wavelet filters, Multiresolution analysis feature of different wavelets, Applications of wavelets in signal and image processing.

Course Outcome: After studying this course, student will be able to
- Understand the properties of various scaling functions and their wavelets.
- Understand the properties of multiresolution analysis.
- Construct the scaling functions using infinite product formula and iterative procedure.
- Implement wavelets in various problems like image compression, denoising etc.
- Develop critical thinking about shortcomings of the state of the art in image processing

Recommended Books:

Prerequisite(s): None

Course Objectives: The objective of the course is to introduce students the areas of computability and fundamental topics in Computer Science. The course also facilities lifelong learning experience in Computer Science by providing the students with foundational material that continues to be applicable even as the discipline rapidly evolves.

Recursive Languages: Recursive definition, Alphabets, Language, Regular expression, Definitions of finite state machine, Transition graphs, Deterministic & non-deterministic finite state machines, Regular grammar, Left linear and right linear, Thomson’s construction to convert regular expression to NDFA & subset algorithm to convert NDFA to DFA, Minimization of DFA, Finite state machine with output (Moore machine and Melay Machine), Conversion of Moore machine to Melay machine & vice-versa.

Properties of Regular languages: Conversion of DFA to regular expression, Pumping lemma, Properties and limitations of finite state machine, Decision properties of regular languages, Application of finite automata.


Uncomputability: Halting problem, Turing enumerability, Turing acceptability and turing decidabilities, Unsolvable problems about turing machines.

Computation Complexity: P, NP and NP complete problems.

Laboratory Work: Lab work will be based on the program design of pattern matching in C language. Program design in LEX using regular expression and integration with YACC

Course Outcomes: Upon completion of the course, students should possess the following skills:
- Master regular languages and finite automata
- Master context-free languages, push-down automata and Turning recognizable languages.
- Be exposed to a broad overview of the theoretical foundations of computer science.
- Be familiar with thinking analytically and intuitively for problem-solving situations in related areas of theory in computer science.

Recommended Books:
Prerequisite(s): None

Course objectives: The course has been introduced with an intention to provide knowledge of wireless communication, media requisites, challenges and a comparative analysis with wired networks. The contents groom a learner in the area of cellular communication, concept of frequency, wireless standards and concept of wireless integration with traditional wired networks.

Introduction to wireless networking, advantages and disadvantages of wireless networking, Characteristics of radio propagation, Fading, multipath propagation

Wireless Communication systems: Evolution of mobile communication generations, Cellular concept, Frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trunking and grade of services, Improving coverage and capacity in cellular systems

Medium Access Control: MAC protocols for digital cellular systems such as GSM, MAC protocols for wireless LANs such as IEEE 802.11,a, b, g and HIPERLAN I and II, The near far effect, Hidden and exposed terminals, Collision avoidance (RTS, CTS) protocols.

Bluetooth: Radio specification, baseband specification, Link manager specification, Logical link control and adaptation protocol.


Laboratory: The lab work will be based on the configuration of wireless LANs using access points, Routers etc, Implementation of WAP protocol stack, Wireless programming using Bluetooth, RFID, GSM and Wi-Fi development kits etc.

Course outcomes: After the completion of this course the student will be able to
- Learn wireless network standards
- Know the construction and working of wireless networks
- Compare and contrast wire and wireless networks
- Understand issues of data communication, security and channelization
- Appreciate concept of wireless technologies

Recommended Books:
Course Objectives: Understanding of basic concepts, services, threats and principles in network security. Comprise and implement various cryptographic techniques. Implement protocols like SSL, SSH. Implementation of email security services, authentication services, web security services. Comprise security services and mechanisms in the network protocol stack. Firewall requirements and its configuration.

Introduction: Security problem in computing, Elementary cryptography introduction, Substitution ciphers, Transpositions encryption algorithms DES, AES, Public key encryption, Uses of encryption, Program security, Secure programs, Non malicious program errors, Viruses and other malicious code, Targeted malicious code, Controls against program threats.

Protection in General Purpose Operating Systems: Protected objects and methods of protection, Memory and address protection, Control of access to general objects, File protection mechanisms, User authentication, Designing, Trusted operating systems, Security policies, Models of security, Trusted operating system design, Assurance in trusted operating systems.


Session hijacking, Spoofing vs hijacking, Steps in session hijacking, Types of session hijacking, Protocol vulnerabilities- examples of protocol vulnerabilities, Secure socket layer/transport layer security, Secure shell (SSH), Firewall architectures, packet filtering, proxy services and bastion hosts.

Network Administration: Introduction, Configuration of DNS, DHCP, and NAT, Mail services- email, News, Administration of mail services, File services, Directory services, Print services, LAN and WAN fundamentals, Network designing, Configuration and management.

Laboratory Work: The lab work will include implementation of algorithms of cryptography in network security. The lab work will include firewall implementation, SSH, Certificates and security tools implementation, Database security, Program security etc. The lab work will also include configuring DNS, DHCP, NAT etc., Router configuration, WAN networking, Building VPN.

Course Outcomes: After Completion of course Students should be able to:
- Understand Security trends.
- Implement various cryptographic algorithms.
- Understand various mechanism to protect Operating System from threats.
- Understand the various type of system attacks and their countermeasures.

Configure a firewall, DNS, DHCP, and NAT, Mail services- email, News, Administration of mail services, File services, Directory services, Print services.

Recommended Books:
Course Objectives: This course deals with the mathematical theory of numerical methods especially finite difference and finite element methods used to solve partial differential equations (PDEs). In this course, students will study algorithms and methods to obtain numerical results for different kind of physically important PDEs system like Laplace, Poisson, Heat and Wave equations. Student will study analysis and applications of finite difference methods and finite element methods for the numerical solutions of various elliptic, hyperbolic and parabolic PDEs.

Parabolic Equations: Numerical solutions of parabolic equations of second order in one space variable with constant coefficients – two and three levels explicit and implicit difference schemes, Truncation errors and stability, Numerical solution of parabolic equations of second order in two space variable with constant coefficients-improved explicit schemes, Larkin modifications, Implicit methods, alternating direction implicit (ADI) methods, Difference schemes for parabolic equations with variable coefficients in one and two space dimensions, Difference schemes in spherical and cylindrical coordinate systems in one dimension.

Hyperbolic Equations: Numerical solution of hyperbolic equations of second order in one and two space variables with constant and variable coefficients-explicit and implicit methods, ADI methods, Difference schemes for first order equations.

Elliptic Equations: Numerical solutions of elliptic equations, Approximations of laplace and biharmonic operators, Solutions of dirichlet, Neumann and mixed type problems with laplace and poisson equations in rectangular, Circular and triangular regions, ADI methods.

Finite Element Method: Introduction to FEM, FEM for Laplace, Poisson, heat flow and wave equations.

Course outcomes: After successful completion of this course, the students should be able to

- Find numerical solutions of heat conduction or diffusion equation in one and two space variables with the aid of Bendre Schmidt explicit scheme, Crank Nicholson scheme, Du-Fort and Frankel Scheme etc.
- Carry out the sensitivity analysis and truncation error in various aforementioned numerical schemes.
- Apply difference schemes in spherical and cylindrical coordinate systems in one dimension parabolic equations
- Calculate the numerical solution of hyperbolic equations of second order in one and two space variables with explicit and implicit methods and ADI method
- Approximate Laplace and biharmonic operators.
- Solve the Dirichlet, Neumann and mixed type problems with Laplace and Poisson equations in rectangular, circular and triangular regions.
- Apply the FEM for Laplace, Poisson, heat flow and wave equations.
Recommended Books:

PMC422 Fluid Mechanics

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Prerequisite(s): None

Course objectives: This course is intended to provide a treatment of topics in fluid mechanics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems. The objective is to provide the student with knowledge of the fundamentals of fluid mechanics and an appreciation of their application to real world problems.

Kinematics: Lagrangian and eulerian methods, Equation of continuity, Stream lines, Path lines and streak lines, Velocity potential and stream function, Irrotational and rotational motions.

Dynamics: Euler’s equation, Bernoulli’s equation, Equations referred to moving axes, Impulsive actions, Vortex motion and its elementary properties, Motions due to circular and rectilinear vortices, Kelvin’s proof of permanence.


Laminar Flow: Stress components in a real fluid, Navier-Stokes equations of motion, Plane poiseuille and couette flows between two parallel plates, Flow through a pipe of uniform cross section in the form of circle, Annulus, Theory of lubrication.

Boundary Layer Flows: Boundary layer thickness, Displacement thickness, Prandit’s boundary layer, Boundary layer equations in two dimensions, Blasius solution, Karman integral equation, Separation of boundary layer flow.

Course Outcomes: After the completion of this course the student will be able to

- demonstrate a deep understanding of the conservation and some constitutive laws governing the behaviour of fluids.
- utilize appropriate mathematical techniques to derive certain well-known results
- Solve real world problem in engineering and can understand their scientific and engineering applications.

Recommended Books:

Prerequisite(s): None

**Course Objectives:** The objective of the course is to introduce basic topics of algebraic coding theory like error correction and detection, linear codes, Hamming codes, finite fields and BCH codes, dual codes and the weight distribution, cyclic codes, generator polynomial and check polynomial.

**Introduction to Coding Theory:** Code words, Distance and weight function, Nearest-neighbour decoding principle, Error detection and correction, Matrix encoding techniques, Matrix codes, Group codes, Decoding by coset leaders, Generator and parity check matrices, Syndrom decoding procedure, Dual codes.

**Linear Codes:** Linear codes, Matrix description of linear codes, Equivalence of linear codes, Minimum distance of linear codes, Dual code of a linear code, Weight distribution of the dual code of a binary linear code, Hamming codes.

**BCH Codes:** Polynomial codes, Finite fields, Minimal and primitive polynomials, Bose-Chaudhuri-Hocquenghem codes.

**Cyclic Codes:** Cyclic codes, Algebraic description of cyclic codes, Check polynomial, BCH and Hamming codes as cyclic codes.

**MDS Codes:** Maximum distance separable codes, Necessary and sufficient conditions for MDS codes, Weight distribution of MDS codes, An existence problem, Reed-Solomon codes.

**Course Outcomes:**
- The students will get a good understanding of the basic concepts and methods of algebraic coding theory.
- They will learn how coding theory is applicable in real world problems.

**Recommended Books:**
Prerequisite(s): None

Course objectives: The objective of the course includes an introduction about different finite element methods in one-, two- and three-dimensions. The course focuses on analyzing variety of finite elements as per the requirements of solutions of differential equations.

Introduction: Finite element methods, History and range of applications.

Finite Elements: Definition and properties, Assembly rules and general assembly procedure, Features of assembled matrix, Boundary conditions.


Element Shapes and Interpolation Functions: Basic element shapes, Generalized co-ordinates, Polynomials, Natural co-ordinates in one- two- and three-dimensions, Lagrange and hermite polynomials, Two-D and three-D elements for C₀ and C¹ problems, Co-ordinate transformation, Iso-parametric elements and numerical integration, Application of finite element methods to elasticity problems and heat transfer problems.

Course outcomes: After the completion of this course the students should be able to
- Formulate simple problems into finite elements.
- Solve the elasticity and the heat transfer problems.
- Solve the complicated two- and three-dimensional problems.
- Appreciate the importance of finite element methods for solving real life problems arising in various fields of science and engineering.

Recommended Books:

PMC425 Topology

Prerequisite(s): None

Course Objectives: This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics.

Topological Spaces: Review of metric spaces, Definition and examples of topological spaces, Topology induced by a metric, Closed set, Closure, Dense subsets, Neighbourhood, Interior, Exterior, Boundary and accumulation points and derived sets, Bases and sub bases, Topology generated by sub bases, Subspaces and relative topology, Continuous function and homeomorphism.

Countable Spaces: First and second countable spaces, Lindelof spaces, Separable spaces, Second countability and separability, Separation axioms (T_0, T_1, T_2, T_3, regular and normal spaces), Urysohn’s lemma, Tietze extension theorem.

Compact and Connected Spaces: Compact spaces and their basic properties, Pseudocompact spaces and countably compact spaces, Connected spaces, Connected sets in the real line, Totally disconnected spaces, Intermediate value theorem, Path connected components, Locally connected spaces, Totally disconnected spaces, Continuous functions and connected sets.


Course Outcomes:

1. Students will be able to use axioms of set algebra.
2. Students will be able to define topology, and its construction.
3. Students will be able distinguish open and closed subsets and their theory.
4. They will be able to understand different metric spaces and understand their need in mathematics.

Recommended Books:

Course Objectives: The purpose of the course is to give a simple account of classical number theory, prepare students to graduate-level courses in number theory and algebra, and to demonstrate applications of number theory (such as public-key cryptography). Upon completion of the course, students will have a working knowledge of the fundamental definitions and theorems of elementary number theory, be able to work with congruences, solve congruence equations and systems of equations with one and more variables, and be literate in the language and notation of number theory. They will also have an exposure to cryptography.

Divisibility: Greatest common divisor, Fundamental theorem of arithmetic, Congruence, Residue classes and reduced residue classes, Euler’s theorem, Fermat’s theorem, Wilson Theorem, Chinese remainder theorem with applications.

Polynomial Congruences: Primitive roots, Indices and their applications, Quadratic residues, Legendre symbol, Euler’s criterion, Gauss’s Lemma, Quadratic reciprocity law, Jacobi symbol.

Arithmetic Functions: $\phi(x)$, $d(x)$, $\mu(x)$, $\sigma(x)$, Mobius inversion formula, Diophantine equations $x^2 + y^2 = z^2$ and its applications to $x^n + y^n = z^n$ when $n = 4$.

Farey Series: Continued fractions, Approximations of reals by rationals, Pell’s equation.

Introduction to Cryptography- Encryption schemes, Cryptanalysis, Block ciphers, Stream ciphers, Affine ciphers, DES and AES algorithms,

Public Key Encryption- RSA cryptosystem, Rabin encryption, Diffie-Hellman key exchange, ElGamal encryption, Cryptographic hash functions,

Course Outcomes

- Students be able to understand the properties of divisibility and prime numbers. Also be able to compute the greatest common divisor and least common multiples and handle linear Diophantine equations.
- Be able to understand the operations with congruences, linear and non-linear congruence equations (with relatively small moduli)
- Student’s will understand and be able to use the founding theorems: Lagrange theorem, Fermat’s little theorem, Wilson’s theorem, concept of a pseudoprime.
- Be able to compute a group of units directly. Compute Euler’s function phi, be able to use a formula for phi to study relations between numbers n and phi(n).
- Understand the basics of RSA security and be able to break the simplest instances.

Recommended Books:

Prerequisite(s): None

Course objectives: The objective of this course is to teach the students the need of fuzzy sets, arithmetic operations on fuzzy sets, fuzzy relations, possibility theory, fuzzy logic, and its applications


Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of operations, Aggregation operations.

Fuzzy Arithmetic: Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals and numbers, Lattice of fuzzy numbers, Fuzzy equations.

Fuzzy Relations: Crisp and fuzzy relations, Projections and cylindric extensions, Binary fuzzy relations, Binary relations on single set, Equivalence, Compatibility and ordering Relations, Morphisms, Fuzzy relation equations.

Possibility Theory: Fuzzy measures, Evidence and possibility theory, Possibility versus probability theory.

Fuzzy Logic: Classical logic, Multivalued logics, Fuzzy propositions, Fuzzy qualifiers, Linguistic hedges.

Uncertainty Based Information: Information and uncertainty, Non specificity of fuzzy and crisp sets, Fuzziness of fuzzy sets.

Applications of Fuzzy Logic: Washing machines, Control systems engineering, Power engineering and Optimization.

Course outcomes: After the completion of this course the student will be able:

- To construct the appropriate fuzzy numbers corresponding to uncertain and imprecise collected data.
- To handle the real world problem in engineering having uncertain and imprecise data.
- To find the optimal solution of mathematical programming problems having uncertain and imprecise data.

Recommended Books:

Prerequisite(s): None

Course objectives: The objective of this course is to teach the basic concepts of non-linear programming problems as well as the methods to solve quadratic programming problems, goal programming problems, dynamic programming problems, multi-objective programming problems and search technique to find the solution of unconstrained optimization problems.

Nonlinear Programming: Convex functions and their subgradients, Differentiable and twice differentiable convex functions and their properties, Convex programming problem, Maxima and minima of convex functions, Generalized convexity, Quasiconvex functions, Strictly and strongly quasiconvex functions, Pseudo convex functions and their properties, Ist order Karush Kuhn Tucker (KKT) optimality conditions.

Quadratic Programming: Wolfe and Beale’s algorithm, Wolfe’s duality and related results.

Goal Programming: Graphical solution.


Dynamic Programming: Deterministic and probabilistic dynamic programming, Bellman’s principal of optimality, Discrete and continuous dynamic programming, simple illustrations.

Multi-Objective Programming: Non dominated criteria vector and efficient point, Weakly and strictly efficient solutions, Proper efficiency and proper non-dominance, Efficient solutions, Domination cones, Weighted sum approach.

Course outcomes: After the completion of this course the student will be able to find solution of any such real life problem which can be formulated as a:

- Quadratic programming problem
- Goal programming problem
- Dynamic programming problem
- Multi-objective programming problem
- Unconstrained optimization problem.

Recommended Books:

PMC429 Theory of Elasticity

Prerequisite(s): None

Course objectives: This course is intended to provide a basic treatment of the formulation of linear elasticity theory and its application to problems of stress and displacement analysis. The objective is to provide the student knowledge of fundamentals of theory of elasticity and an appreciation of their application to the different fields of research.

Tensor Algebra: Scalar, Vector, Matrix and tensor definition, Index notation, Kronecker delta and alternating symbol, Coordinate-transformation, Cartesian tensor of different order, Properties of tensors, Isotropic tensors of different orders and relation between them, Symmetric and skew-symmetric tensors, Covariant, Contra variant and mixed tensors, Sum and product of tensors.

Analysis of Stress: Stress vector, Stress components, Stress tensor, Symmetry of stress tensor, Stress quadric of Cauchy, Principal stress and invariants, Maximum normal and shear stresses.

Analysis of Strain: Affine transformations, Infinitesimal affine deformation, Geometrical interpretation of the components of strain, Strain quadric of Cauchy, Principal strains and invariants, General infinitesimal deformation, Finite deformations, Examples of uniform dilatation, Simple extension and shearing strain.

Equations of Elasticity: Generalized Hooke’s law, Hooke’s law for Homogeneous isotropic media, Elastic moduli for isotropic media, Equilibrium and dynamic equations for an isotropic elastic solid, Beltrami-Michell compatibility equations, Strain energy function.


Applications: To variousto various media: Porous, Reinforced and viscoelastic media, Extension of theory of elasticity to thermoelasticity, Microcontinuum theory.

Course outcomes: After the completion of this course the student will be able to
- demonstrate a deep understanding of the conservation, constitutive laws and equation of motion governing the behaviour of solids
- utilize tensor notation in deriving the analytical results.
- Be able to use analytical techniques to predict deformation, internal force and failure of simple solids and structural components
- apply various discussed theories in the concerned fields.

Recommended Books:

Course Objectives:
The goal of this course is to familiarize the students with the basic observed properties of stars and to provide them the knowledge of basic physics and fundamental properties that govern stars and their structures. The aim of this course is also to understand mathematical techniques to solve the stellar structure equations and apply the basic theory of stellar structures on analytical models.


Equations of State: Pressure as function of temperature and density for: Photons, Ideal gas, Degenerate electron gas, Mean molecular weight, Lonization.


Boundary Value Problems: Shooting method and relaxation method, Applications to stellar structure with detailed discussion of Henyey scheme and EZ – Code.

Stellar modeling and Numerical Calculations: Russell-Voigt theorem, Limits to the mass, Solving the coupled equations, Simple analytic stellar models: Polytropes and other relations, Numerical models, The Eddington luminosity, Dimensional analysis and mass-radius relations, The HR diagram.


Course Outcomes:
On the successful completion of the course, student should have familiarity with the basic observed properties of stars, understanding of the basic physics and fundamental properties that govern star and their structure, and knowledge of the mathematical methods to solve stellar structure equations and to apply them on theoretical models.

Recommended Books: