List of Interdisciplinary/Allied Courses

The interdisciplinary/allied courses are given in Table 3. A student may choose any Four courses from the Table 3, selecting Two courses in each of the 7th and 8th semesters.

Table 3: List of Interdisciplinary/Allied Courses for 7th and 8th Semesters

Interdisciplinary	Course Code	Course Title	Credit Hours
Physics	MPHY-410	Fluid Mechanics	3
	MPHY-411	Quantum Mechanics	3
	MPHY-412	Special Theory of Relativity	3
	MPHY-413	Electromagnetic Theory	3
	MPHY-414	Introduction to Manifolds	3
	MPHY-415	Lie Symmetries	3
Computer Science	MACS-410	Digital Logic Design	3
	MACS-411	Database Management System	3
	MACS-412	Introduction to Algorithms	3
	MACS-413	Programming Fundamentals	3
	MACS-414	Web Programming	3
	MACS-415	Object Oriented Programming	3
	MACS-416	Quantum Computing	3
	MACS-417	Fundamentals of Fuzzy Systems	3
	MACS-418	Computer-Aided Geometric Design	3

COURSE OUTLINES OF INTERDISCIPLINARY/ALLIED COURSES

The course outlines of interdisciplinary/allied courses are given below. A student may choose any Four courses, selecting Two courses in each of the 7th and 8th semesters.

Course Title: Fluid Mechanics

Course Code: MPHY-410

Course Type: Allied/Interdisciplinary

Prerequisites: Fundamentals of Mechanics

Credit Hours: 3 (3 + 0)

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

- Understand and use force analysis in static and moving fluids to analyze fluid flow systems.
- Know how to apply the various methods of analysis in fluid mechanics (the Reynolds Transport Equation -Control Volume Analysis and differential approach) to solve real-life fluid flow problems.
- Select and use flow visualization tools (e.g., Timelines, Streamlines, Pathlines, and Streaklines) to analyze and understand the main features of a certain fluid flow.
- Comprehends the concepts of boundary layer, displacement thickness, and flow separation and be able to use these concepts to simplify the analysis of real flows.
- Understand the concept of similarity and dimensional analysis and be able to use it to develop and carry out model-prototype analysis.

Course Contents:

- **Introduction:** Historical Background, Fluids and their properties, continuum concepts, Viscosity and Newton's viscosity law, Classification of fluid and flows.
- **Fluid Kinematics:** Lagrangian and Eulerian specifications, Local, convective and total rates of change, Flow along a curve, Circulation, Irrotational fluid motion, Velocity potential, Streamlines, Pathlines, Streaklines, Vorticity, Vortex lines and vortex sheets, Conservation of mass (Equation of continuity), Boundary conditions.
- **Fundamental Equations:** Surface and body forces, Hydrostatic equation, Conservation of linear momentum (Euler's equation of motion), Bernoulli's Equations, Stress and strain tensors, Constitutive equations, Navier-Stokes's equations, Energy equation.
- **Parallel Flows:** Steady unidirectional flow, Poiseuille flow, Couette flow, Hagen-Poiseuille flow, Stokes first problem, Stokes second problem.

Recommended Books:

1. Chia-Shun, Y., *Fluid Mechanics*, McGraw Hill Book Company, 1974.

2. Curie, I. G., *Fundamentals of Mechanics of Fluids*, CRC Press, 4th edition, 2012.

3. Pritchard, J., and Leylegian, J. C., *Fox and McDonald's Introduction to Fluid Mechanics*, John Wiley & Sons Inc., 8th edition, 2011.

4. H. Schlichting, K. Gersten, E. Krause and H. Oertel, Jr., *Boundary-Layer Theory*,Springer, 8th edition, 2004.

5. White, F., *Fluid Mechanics*, McGraw Hill, 8th edition, 2015.

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Course Title: Quantum Mechanics

Course Code: MPHY-411

Course Type: Allied/Interdisciplinary

Prerequisites: Linear Algebra & Probability Theory.

Credit Hours: 3 (3 + 0)

Course Objectives: By the end of the course, students will be able to:

- Recognize the limitations of classical mechanics which urge the need to develop new theory to address these limitations.
- Familiarize the students with the mathematical formalism of quantum mechanics to describe the dynamics of sub-atomic particles.
- Develop the interest in the applications of quantum mechanical formalism such as finding the allowed energy levels, shapes of atomic orbitals and spectral properties of Hydrogen atom.

Course Contents:

Preliminaries: Wave-particle duality, Young's double slit experiment, Bohr's atomic model, de Broglie hypothesis, Heisenberg uncertainty principle, Probability waves and Born's rule.

Mathematical Formalism of Quantum Mechanics: Observables and operators, Measurement in quantum mechanics, The state/wave function and expectation values, Schrodinger's wave equation, Time evolution of the state function and initial-value problem in quantum mechanics, Parity operators, Dirac Notation for state functions and operators.

Applications of Quantum Mechanics: Superposition principal and its physical interpretation. Commutation relations and Heisenberg uncertainty principle. Comparison of classical and quantum mechanical harmonic oscillator. Eigen functions of harmonic oscillator. Schrodinger's wave equation in three dimensions and its application to Hydrogen atom.

Recommended Books:

1. Bransden, B.H. and Joachain, C.J., *Quantum Mechanics*, Prentice Hall Publisher, 2nd Edition, 2000.

2. Liboff, R., *Introductory Quantum Mechanics*, 4th Edition, Pearson, 2002.
3. Griffiths, D. J. and Schroeter, D. F., *Introduction to Quantum Mechanics*, Cambridge University Press, 3rd Edition, 2018.
4. Sakurai, J. J. and Napolitano, J., *Modern Quantum Mechanics*, Cambridge University Press, 3rd Edition, 2020.
5. Zettili, N., *Quantum Mechanics: Concepts and Applications*, Wiley, 3rd Edition, 2022.

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Course Title: Special Theory of Relativity

Course Code: MPHY-412

Course Type: Allied/Interdisciplinary

Prerequisites: Classical Mechanics

Credit Hours: 3 (3 + 0)

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

- Provide students with a thorough understanding of the Special Theory of Relativity.
- Cover the historical context, key principles, and mathematical formulations of the theory.
- Master Einstein's postulates and the fundamental concepts of spacetime.
- Understand Lorentz transformations and the invariance of the speed of light.
- Explore relativistic effects on time, space, energy, and momentum.
- Develop mathematical skills to analyze and solve relativistic problems.
- Highlight the applications and implications of relativity in modern physics.
- Enhance comprehension of phenomena such as time dilation, length contraction, and mass-energy equivalence.

Course Contents:

Introduction: Fundamental concepts: Inertial/Non-Inertial frame of references, Michelson-Morley experiment, Galilean transformation, Lorentz-Fitzgerald contraction, Ether theory.

Derivation of Special Relativity: Einstein's formulation of special relativity, The Lorentz transformation, Length contraction, time dilation and simultaneity, Lorentz invariance, The velocity addition formulae, Three dimensional Lorentz transformations.

The Four-Vector Formulation of Special Relativity: The four-vector formalism, Spacetime intervals and their invariance, The Lorentz transformations in 4-vectors, The Lorentz and Poincare groups, The null cone structure, Proper time.

Applications of Special Relativity: Relativistic kinematics, The Doppler shift in relativity, The Compton effect, Relativistic momentum and energy, The concept of mass in relativity, Particle scattering, Binding energy, particle production and particle decay.

Electromagnetism in Special Relativity: Review of electromagnetism, The electric and magnetic field intensities, The electric current, Introduction to the electromagnetic field tensor, Maxwell's equations and electromagnetic waves, The four-vector formulation of Maxwell's equations

Recommended Books:

1. Barton, G., *Introduction to the Relativity Principle*, Wiley, 1st edition, 1999.
2. Qadir, A., *Relativity : An Introduction To The Special Theory*, World Scientific Publishing Co., 1989.
3. Rindler, W., *Introduction to Special Relativity*, Clarendon Press, 2nd edition, 1991.
4. Rosser, W. G. V., *Introductory Special Relativity*, CRC Press, 1st edition, 1992.
5. Saleem, M., and Rafique, M., *Special Relativity*, Ellis Horwood Ltd., 1992.

Course Title: Electromagnetic Theory

Course Code: MPHY-413

Course Type: Allied/Interdisciplinary

Prerequisites: Fundamentals of Physics

Credit Hours: 3 (3 + 0)

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

- Develop a deep understanding of the behavior of electric and magnetic fields in various media.
- Enhance the ability to apply advanced mathematical techniques, such as vector calculus, differential equations, and complex analysis, to solve problems in electromagnetic theory.
- Analyze the principles of electromagnetic wave propagation, reflection, refraction, and transmission in different media.

Course Contents:

Electrostatic Fields: Coulomb's law, the electric field intensity and potential, Gauss's law and deductions, Poisson and Laplace equations, Conductors and condensers, Dipoles, the linear quadrupole, Potential energy of a charge distribution, Dielectrics, The polarization and the displacement vectors

Magnetostatic Fields: The Magnetostatic law of force, The magnetic induction, The Lorentz force on a point charge moving in a magnetic field, The divergence of the magnetic field, The vector potential, The conservation of charge and the equation of continuity, The Lorentz condition, The curl of the magnetic field, Ampere's law and the scalar potential.

Steady and Slowly Varying Currents: Electric current, linear conductors, Conductivity, resistance, Kirchhoff's laws, Current density vector, Magnetic field of straight and circular current, Magnetic flux, vector potential, Forces on a circuit in magnetic field.

Electromagnetic Waves: Plane electromagnetic waves in homogeneous and isotropic media, The Poynting vector in free space, Propagation plane electromagnetic waves in non-conductors, Propagation plane electromagnetic waves in conducting media.

Recommended Books:

1. Owen, G. E., *Introduction to Electromagnetic Theory*, Dover, 2003.
2. Corrison, D. and Lorrison, P., *Introduction to Electromagnetic Fields and Waves*, W. H. Freeman and Company, London, 1962.
3. Reitz, J. R., Milford, F. J. and Christy, R. W., *Foundations of Electromagnetic Theory*, Addison-Wesley Publishing Co., 2009.
4. Jackson, J. D., *Classical Electrodynamics*, Wiley, third edition, 2021.
5. Griffiths, D. J., *Introduction to Electrodynamics*, Prentice-Hall, 5th edition, 2023.

Course Title: Introduction to Manifolds

Course Code: MPHY-414

Course Type: Allied/Interdisciplinary

Prerequisites: Linear Algebra & Differential Geometry

Credit Hours: 3 (3 + 0)

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

- Describe basic ideas of smooth manifolds with examples
- Describe algebras and analysis on the manifolds
- Understand basic examples and structures of Lie groups

Course Contents:

Manifolds and Differentiable Structures: Basic definition and examples, Topological manifold, Smooth manifold, Atlas and charts, Smooth structures, Transition maps, Partial derivatives, Critical points, Immersion theorem.

Tangent and Cotangent Bundle: Tangent space of $\mathbb{R}^n$, Tangent space of an imbedded manifold, Vector bundle, Tangent and cotangent bundle of a manifold, Derivations and vector fields on a manifold.

Lie Groups: Basic definition and examples of a Lie group, Classical groups, Metric and norm on real and complex vector spaces, Inner product and bilinear forms, Classical groups, Infinitesimal transformations, Lie group generators.

Matrix Lie Groups: Definition of a matrix Lie group, Special linear groups, Orthogonal groups, Special orthogonal groups, Rotation groups, Generators of a matrix group, Lie algebra, Lie algebras as tangent to identity of a Lie group.

Applications of Manifolds to Physics: Kähler Manifold, Calabi-Yau manifold and its applications.

Recommended Books:

1. Anthony, W. K., *Lie Groups: Beyond an Introduction*, Birkhauser, 1996.
2. Brian, C. H., *Lie Groups, Lie Algebras, and Representations*, Springer, 2003.
3. Lee, J. M., *Introduction to Smooth Manifolds*, Springer, 2000.
4. Lovett, S., *Differential Geometry of Manifolds*, Chapman and Hall/CRC, 2nd Edition, 2019.
5. Tu, L. W., *Introduction to Manifolds*, Springer, 2nd edition, 2008.

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Course Title: Lie Symmetries

Course Code: MPHY-415

Course Type: Allied/Interdisciplinary

Prerequisites: Algebra & ODEs

Credit Hours: 3 (3 + 0)

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

- Describe basic ideas and examples of Lie algebras
- Identify different low dimensional Lie algebras
- Understand basic ideas of Symmetries of differential equations

Course Contents:

Lie Algebras: Review of algebras, vector spaces and rings, Ideals, basic definition and examples of Lie algebras, Structure constants.

Classification of Lie Algebras: Solvable Lie algebras, Nilpotent Lie algebras, Cartan subalgebras, Killing form, The Cartan decomposition of a semisimple Lie algebra, The Lie algebra $sl(n,\mathbb{C})$, The root system and the Weyl Group, The Cartan Matrix and the Dynkin Diagram.

Symmetries: Symmetries of planar objects, definition and examples of Symmetries of an ordinary differential equation, Lie symmetries of ordinary differential equations.

Solution of Ordinary Differential Equations: Linearized symmetry conditions, infinitesimal generators, One parameter Lie group, reduction of order, invariant solution.

Recommended Books:

1. Erdman, K. and Wildon J., *Introduction to Lie Algebras*, Springer Undergraduate Mathematics Series, 2002.

2. Brian, C. H., *Lie Groups, Lie Algebras, and Representations*, Springer, 2003.

3. Peter, E. H., *Symmetry Methods for Differential Equations: A Beginner's Guide*, Cambridge University Press, 2000.

4. Hans, S., *Differential Equations: Their Solution Using Symmetries*, Cambridge University Press, 1989.

Course Title: Digital Logic Design

Course Code: MACS-410

Course Type: Allied/Interdisciplinary

Prerequisites: Applications of ICT

Credit Hours: 3 (3 + 0)

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

- Interpret, convert and represent different number systems and perform binary arithmetic.
- Design and analyze combinational logic circuits and sequential logic circuits.
- Design efficient combinational and sequential logic circuit implementations from functional description of digital systems.

Course Contents:

- **Number Systems:** Decimal, Binary, Octal, Hexadecimal, Conversions, Arithmetic operations.

- **Boolean Algebra and Logic Gates:** Digital logic gates, Boolean postulates, Boolean functions and their complements, Sum of MinTerms, Product of MaxTerms, Standard forms.

- **Gate Level Minimization:** Karnaugh maps, Two variable maps, Three variable maps, Four variable maps, Digital circuits using gates, Digital circuits using NAND gates.

- **Combinational Logic:** Analysis and design, Code converters, Half adder, Full adder, Multiplier Decoders and Encoders Multiplexers.

- **Registers and Counters:** Simple registers, Registers with parallel Load, Shift registers/Serial to parallel converters, Asynchronous/ Synchronous counter, Binary counter, Arithmetic Circuits, State Machines.

Recommended Books:

1. Brown, S. and Vranesic, Z., *Fundamentals of Digital Logic with Verilog Design*, McGraw Hill, 3rd edition, 2013.

2. Floyd, T., *Digital Fundamentals*, Pearson, 11th edition, 2014.

3. Morris Mano, M., Kime, C. and Martin, T., *Logic and Computer Design Fundamentals*, Pearson, 5th edition, 2015.

4. Tocci, R. J., Widmer, N. and Moss, G., *Digital Systems: Principles and Applications*, Pearson, 11th edition, 2010.

Course Title: Database Management System

Course Code: MACS-411

Course Type: Allied/Interdisciplinary

Prerequisites: Applications of ICT

Credit Hours: 3 (3 + 0)

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

- Understand the basic concepts and the applications of database systems.
- Master the basics of SQL and construct queries using SQL.
- Understand the relational database design principles.
- Familiar with the basic issues of transaction processing.

Course Contents:

- **File Systems and Databases:** A file system critique, Database systems, Database approach vs file-based system, Database architecture, Three level schema architecture, Data independence, Database models.

- **Relational Database Management System (RDBMS):** Logical view of Data, Entities and Attributes, Tables and their Characteristics, Keys, Relational data model, Attributes, schemas, Tuples, Domains, Relation instances, Keys of relations, Integrity constraints.

- **Relational Algebra:** Relational database operators: Selection, Projection, Cartesian product, Types of joins.

- **Entity Relationship (E-R) Modeling:** Basic Modeling Concepts, Entity sets, Attributes, Relationship, Entity-relationship diagrams.

- **Normalization of Database Tables:** Objectives, Forms, Normalization and Database Design, functional dependencies, normal forms, Denormalization.

- **Structured Query Language (SQL):** Introduction, DDL Commands, Joins and subqueries in SQL, Grouping and aggregation in SQL, DML Commands, DCL Commands, Complex Queries and SQL Functions, Procedural SQL, Triggers, Stored procedures.

- **Transaction Management:** Transaction, ACID Properties of transaction, Recovery.

Recommended Books:

1. Coronel, C. and Morris, S., *Database Systems: Design, Implementation & Management*, 13th Edition, Cengage Learning, 2017.

2. Connolly, T. and Begg, C., *Database Systems: A Practical Approach to Design, Implementation and Management*, 6th Edition, Pearson, 2015.

3. Elmasri, R. and Navathe, S. B., *Fundamentals of Database Systems*, 7th Edition, Pearson, 2016.

4. Hoffer, J. A., Venkataraman, R. and Topi, H.,*Modern Database Management*, 12th Edition, Pearson, 2015.

5. McLaughlin, M., *Oracle Database 11g PL/SQL Programming*, 1st Edition, McGraw-Hill Education, 2008.

Course Title: Introduction to Algorithms

Course Code: MACS-412

Course Type: Allied/Interdisciplinary

Prerequisites: Introduction to Graph Theory

Credit Hours: 3 (3+0)

Course Objectives: This is a fundamental course on algorithms in computer science. After completion of this course, the students will be able to:

- Analyze the asymptotic performance of algorithms.
- Solve recurrence relations.
- Apply divide and conquer strategy.
- Understand the concepts of graphs and trees and related algorithms.

Course Contents:

- **Introduction:** What is an algorithm?, History, Properties of algorithms, The growth of functions.

- **Complexity of Algorithms:** Asymptotic notations, Basic definitions of algorithmic complexity (worst case, average case), Complexity of matrix multiplication, Complexity of searching and sorting algorithms.

- **Recursion:** Recursive definition, Recursive algorithms, Divide-and-conquer algorithms, Recurrence relations. Methods for solving recurrences: Substitution method, Recursion tree method, Master method.

- **Graphs and Related Algorithms:** Graph terminology, Adjacency list, Adjacency matrix, and Adjacency list representation of graph. Elementary graph operations: Breadth first search and depth first search. Shortest path algorithms.

- **Trees and Related Algorithms:** Binary tree, Spanning Tree, Algorithms for spanning tree: Depth-first search algorithm, breadth-first search algorithm. Minimum spanning trees, Algorithms for Minimum Spanning Trees: Prim's algorithm, Kruskal's algorithm. Tree traversal (Inorder, Preorder an Postorder).

Recommended Books:

1. Cormen, T. H., Leiserson, C. E. et al., *Introduction to Algorithms*, MIT Press, 4th edition, 2022.

2. Miller, B. and Ranum, D., *Problem Solving with Algorithms and Data Structures Using Python*, Franklin, Beedle & Associates, 2nd edition, 2011.

3. Rosen, K., *Discrete Mathematics and Its Applications*, McGraw-Hill Education, 7th edition, 2011.

4. Samanta, D., *Classic Data Structures*, Prentice Hall, 2nd edition, 2009.

5. Weiss, M. A., *Data Structures and Algorithm Analysis in C*, Pearson, 2nd edition, 1996.

Course Title: Programming Fundamentals

Course Code: MACS-413

Course Type: Allied/Interdisciplinary

Prerequisites: Applications of ICT

Credit Hours: 3 (2 + 1)

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

- Write, compile and debug programs in C language.
- Use different data types in a computer program.
- Design programs involving decision structures, loops, arrays, and functions.
- Identify the difference between call by value and call by reference.
- Use pointers to understand the dynamics of memory.
- Perform file handling operations and manage memory dynamically.

Course Contents:

- **Introduction to the C Language:** Algorithm, Pseudo code, Flowchart, Background, C Programs, Identifiers, Data Types, Variables, Constants, Input / Output, Operators (Arithmetic, relational, logical, bitwise, etc.), Expressions, Precedence and Associatively, Expression Evaluation, Type conversions.
- **Control Statements:** Basic data types and variables, input/output constructs, arithmetic, comparison, and logical operators, conditional statements and execution flow for conditional statements, repetitive statements and execution flow for repetitive constructs.
- **Functions:**Introduction to Structured Programming, Functions – basics, user-defined functions, inter-function communication (call by value, call by reference), Standard functions, Storage classes – auto, register, static, extern, scope rules, arrays to functions, recursive functions, example C programs.
- **Arrays:** Basic concepts, one-dimensional arrays, two-dimensional arrays, multidimensional arrays, C programming examples.
- **Pointers:** Introduction (Basic Concepts), pointers to pointers, compatibility, Pointer Applications, Arrays and Pointers, Pointer Arithmetic, memory allocation functions, array of pointers, pointers to void, pointers to functions, command-line arguments, Introduction to structures and unions.
- **File Handling:** Basics of file operations, Reading from and writing to files, File pointers, Error handling in file operations, Binary and text file handling.
- **Memory Management:** Dynamic memory allocation, malloc, calloc, realloc, and free functions, Memory leaks and their prevention, Use of pointers in dynamic memory management.

Recommended Books:

1. Deitel, P. and H. Deitel, H., *C++ How to Program*, Pearson, 10th edition, 2016.
2. Gaddis, T., *Starting Out with C++ from Control Structures to Objects*, Pearson, 9th edition, 2017.
3. Hanly, J. R. and Koffman, E. B., *Problem Solving and Program Design in C*, Pearson, 7th edition, 2012.
4. Kernighan, B. W. and Ritchie, D. M., *C Programming Language*, Pearson, 2nd edition, 1988.

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Course Title: Web Programming

Course Code: MACS-414

Course Type: Allied/Interdisciplinary

Prerequisites: Programming Fundamentals

Credit Hours: 3 (2 + 1)

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

- Demonstrate and understand the basic concepts of web programming.
- Write well-structured, easily maintained, standards-compliant, web pages using HTML and CSS code.
- Use JavaScript to add dynamic content to pages that meet specific needs and interests.

Course Contents:

- **Introduction:** Web Applications, TCP/IP Application Services.
- **Web Servers:** Basic Operation, Virtual hosting, Chunked transfers, Caching support, Extensibility. SGML, HTML5, CSS3.
- **XML Languages and Applications:** Core XML, XHTML, XHTM MP.
- **Web Services:** SOAP, REST, WML, XSL. Operations, Processing HTTP Requests, Processing HTTP Responses, Cookie Coordination, Privacy and P3P, Complex HTTP Interactions, Dynamic Content Delivery. Server Configuration. Server Security.
- **Web Browsers Architecture and Processes:** Active Browser Pages: JavaScript, DHTML, AJAX. JSON.
- **Approaches to Web Application Development:** Programing in any Scripting language. Search Technologies, Search Engine Optimization. XML Query Language, Semantic Web, Future Web Application Framework.

Recommended Books:

1. Deitel, P. and H. Deitel, H., , *Java How to Program*, Pearson, 11th edition, 2017.
2. Hall, M. and Brown, L., *Core Servlets and JavaServer Pages*, Pearson, 2nd Edition, 2017.

Course Title: Object Oriented Programming

Course Code: MACS-415

Course Type: Allied/Interdisciplinary

Prerequisites: Programming Fundamentals

Credit Hours: 3 (2 + 1)

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

- Understand the object oriented programming paradigm and concepts of objects and classes.
- Apply the concepts of object-oriented programming principles.
- Design daily-life applications using object oriented programming.

Course Contents:

Introduction: Object-oriented design, History, Advantages of object-oriented design.

Object Oriented Programming: Terminology and features, Classes, Objects, Data encapsulation, Constructors, Destructors, Access modifiers, Const vs non-const functions, Static data members & functions, Function overloading, Operator overloading, Identification of classes and their relationships, Composition, aggregation, Inheritance, Multiple inheritances, Polymorphism, Abstract classes, Interfaces.

Recommended Books:

1. Deitel, P. and H. Deitel, H., *C++ How to Program*, Pearson, 10th edition, 2016.
2. Gaddis, T., *Starting Out with C++ from Control Structures to Objects*, Pearson, 9th edition, 2017.
3. Hanly, J. R. and Koffman, E. B., *Problem Solving and Program Design in C*, Pearson, 7th edition, 2012.
4. Kernighan, B. W. and Ritchie, D. M., *C Programming Language*, Pearson, 2nd edition, 1988.

Course Title: Quantum Computing

Course Code: MACS-416

Course Type: Allied/Interdisciplinary

Prerequisites: Linear Algebra & Functional Analysis

Credit Hours: 3 (3 + 0)

Course Objectives: Students will be able to:

- Familiarize the students with classical computing concepts and their limitations.
- Discuss the preliminary ideas and concept used in quantum computing and information and to enable the students to compare classical and quantum computing paradigms.
- Provide various applications and examples of quantum computing which may enhance the students understanding and insight regarding latest trends in the field of quantum computing and quantum information theory.

Course Contents:

Preliminaries: Classical computer technology and historical background, Basic principles and postulates of quantum mechanics: Hilbert space, quantum states, evolution of quantum state, quantum measurement, superposition, operator function, density matrix representation.

Quantum States: Comparison of bits and qubits, Pure and mixed quantum states, Bloch sphere representation of pure and mixed quantum states, Entangled and separable quantum states, Quantum entanglement, EPR states and Bells inequality, Measures of quantum entanglement, No-cloning theorem, Schmidt decomposition, Positive operator valued measurements (POVM)

Quantum Gates and Logic: Single qubit operation, Controlled operations, Measurement universal quantum gates, CNOT gate quantum circuits comparison with classical computing

Applications of Quantum Computing: Deutsch algorithm, Deutsch-Jozsa algorithm, Simons problem, Quantum phase estimation algorithm, Quantum Fourier transform and eigen value problem, Quantum search algorithm, Quantum cryptography and Shors algorithm, Complexities of the quantum algorithms and quantum supremacy quantum error detection and correction

Recommended Books:

1. Bouwmester, P., Ekert, A. K. and Zeilinger, A., *The Physics of Quantum Information*, Springer, 1st Edition, 2000.

2. Brylinsky, R. K. and Chen, G., *Mathematics of Quantum Computation*, Chapman and Hall/CRC, 1st Edition, 2002.

3. Kaye, P., Laflamme, R. and Mosca, M., *An Introduction to Quantum Computing*, Oxford University Press, 1st Edition, 2007.

4. Nielson, M. A., Chuang, I. L., *Quantum Computation and Quantum Information*, Cambridge University Press, 10th Edition, 2011.

5. Rieffel, E. G. and Polak, W. H., *Quantum Computing: A Gentle Introduction*, The MIT Press, 1st Edition, 2014.

Course Title: Fundamentals of Fuzzy Systems

Course Code: MACS-417

Course Type: Allied/Interdisciplinary

Prerequisites: Quantitative Reasoning & Graph Theory

Credit Hours: 3 (3 + 0)

Course Objectives: A fuzzy system is a system of variables that are associated using fuzzy logic. A fuzzy controller uses defined rules to control a fuzzy system based on the current values of input variables. The study focuses mainly on fuzzy models based on Zadeh's compositional rule of inference. After completion of this course, the students will be able to:

- Describe the basic concepts of fuzzy sets and fuzzy logic.
- Utilize the fuzzy set theory on algebraic structures.
- Apply fuzzy methods to model and solve various engineering problems.

- Apply fuzzy inference systems in control systems and decision support systems.

Course Contents:

Fuzzy Set Theory: Fuzzy sets (membership function, cardinality, normality), Fuzzy set operations (union, intersection, complementation), Distances between fuzzy sets (Hamming distance, normalized Hamming distance, Euclidean distance, normalized Euclidean distance), Similarity measures. Fuzzy relation and composition, Fuzzy function. Fuzzy numbers (Triangular fuzzy number, Trapezoidal fuzzy number), Arithmetic operations of fuzzy numbers. Multipolar (m-polar) fuzzy sets.

Fuzzy Graph Theory: Fuzzy graphs, Regular fuzzy graphs, m-polar fuzzy graphs, Certain types of m–polar fuzzy graphs, m–polar fuzzy labeling graphs, Applications of m–polar fuzzy graphs.

Fuzzy Control Systems & Fuzzy Expert Systems: Review of classical logic, Fuzzy logic, Linguistic variable, Fuzzy truth qualifier, Fuzzy inference, Fuzzy rules and implication, Defuzzification, Fuzzy logic controller, Configuration of fuzzy logic controller, Fuzzy expert systems.

Recommended Books:

1. Akram, M., *m-Polar Fuzzy Graphs*, Studies in Fuzziness and Soft Computing, Springer, 2019.

2. Dubois, D. and Prade, H., *Fuzzy Sets and Systems: Theory and Applications*, Academic Press, 1980.

3. Lee, K. H., *First Course on Fuzzy Theory and Applications*, Springer Berlin, Heidelberg, 2009.

4. Klir, G. J. and Yuan, B., *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Pearson College Div., 1995.

5. Mathew, S., Mordeson, J. and Malik, D. S., *Fuzzy Graph Theory*, Studies in Fuzziness and Soft Computing, Physica Verlag, Heidelberg, 2018.

6. Zimmermann, H. -J. *Fuzzy Set Theory and Its Application*, Studies in Fuzziness and Soft Computing, Springer, 2001.

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Course Title: Computer-Aided Geometric Design

Course Code: MACS-418

Course Type: Allied/Interdisciplinary

Prerequisites: Calculus & Linear Algebra

Credit Hours: 3 (3 + 0)

Course Objectives: This course provides an in-depth understanding of approximation techniques, including linear, bilinear, and multilinear interpolants, polynomial and spline-based methods, and parametric curves and surfaces, along with convergence properties and error estimation. Applications span computer-aided geometric design (CAGD), computer graphics (CG), computer-aided engineering (CAE), and differential geometry (geometric characteristics, quasi-minimal and quasi-harmonic surfaces). Students will gain theoretical and computational skills to tackle problems in geometric modeling, data fitting, and related areas. The course aims to achieve the following objectives:

- Understand various approximation techniques and their applications across different disciplines of mathematics.
- Understand linear, bilinear, and multilinear interpolants, the least squares method, polynomial, and spline-based approximations.
- Analyze convergence properties and error estimation for different approximation methods.
- Understand Bézier surfaces based on various Bernstein polynomials, Hermite interpolants, and Coons patches, and their geometric characteristics.

Course Contents:

Review of Interpolation: Linear, bilinear, trilinear, and multilinear interpolants, Lagrange's method, Divided difference method, Newton polynomials, Gausss forward interpolation formula, Gauss backward interpolation formula.

Hermite interpolation: Hermite interpolating polynomials, Convergence analysis and error estimation.

Polynomial Approximation: Introduction to curve fitting, Transformations for data linearization, Least squares method for linear and nonlinear functions, including polynomial, exponential, logarithmic, power, rational, sinusoidal, Gaussian, sigmoidal, hyperbolic, piecewise linear, and trigonometric functions. Padé approximation, Chebyshev polynomials, and Legendre polynomials.

Parametric Curves: Bézier and spline forms, including algebraic forms, Hermite splines, B-splines, control point representations, Bernstein polynomials and Bézier curves, rational functionals, and barycentric coordinates. Detailed analysis of quadratic and cubic forms with their matrix representations. General splines, cubic Hermite splines, and end conditions for cubic splines: clamped, natural, second derivative, periodic, and not-a-knot conditions.

Parametric Surfaces: Blending functions, Tensor product surfaces and their geometric interpretation. Various Bézier surfaces: Classical and generalized Bézier surfaces based on modified Bernstein polynomials (including q-Bernstein, (p,q)-Bernstein, shifted knots, and λ-Bernstein polynomials). Properties and algorithms: convex hull property, symmetry, affine transformation and invariance property, variation diminishing property, algorithms to compute Bézier curves and surfaces. Hermite cubic interpolants and bicubically blended Coons patches.

Recommended Books:

1. Bartels, R. H., Bealty, J. C. and Beatty, J. C., *An Introduction to Spline for use in Computer Graphics and Geometric Modeling*, Morgan Kaufmann Publisher, 2006.

2. Farin, G., *Curves and Surfaces for Computer Aided Geometric Design: A Practical Guide*, Morgan Kaufmann; 5th edition, 2001.

3. Mortenson, M. E., *Geometric Modeling*, Industrial Press, 2006.

4. Schumaker, L. L., *Spline Functions: Basic Theory*, John Wiley and Sons, 1993.

5. Yamaguchi, F., *Curves and Surfaces in Computer Aided Geometric Design*, Springer Berlin, Heidelberg, 2013.

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