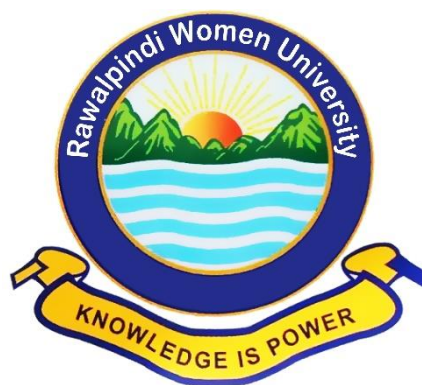


**CURRICULUM
OF
BS MATHEMATICS
(with One Minor)**

(2026)



**RAWALPINDI WOMEN UNIVERSITY,
RAWALPINDI**

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Vision

To develop strong foundational knowledge and analytical thinking in the mathematical sciences by providing high quality education that nurtures problem solving skills, computational competence, leadership abilities, and lifelong learning, empowering women to contribute effectively both personally and professionally to society.

Mission

The program aims to provide high-quality education in mathematics that strengthens conceptual understanding, analytical and computational skills, and modern modeling techniques. We are committed to empowering female students through education, mentorship, and skill development, preparing confident, multidimensional graduates who can contribute effectively to academia, diverse career fields, and society.

1 Program Objectives and Outcomes

i. Strong Foundation of Mathematics

Graduates will demonstrate strong knowledge of fundamental mathematical concepts and analytical techniques.

ii. Enhance Confidence and Capabilities

Develop and implement mentorship programs specifically tailored to female students, aimed at enhancing their confidence and capabilities in mathematics, thereby empowering them to excel academically and professionally.

iii. Foster Practical Problem Solving Skills

Develop and incorporate practical problem solving and modern modeling techniques into the curriculum, with a focus on encouraging female students to pursue their interests and develop expertise in mathematics.

iv. Cultivate Leadership and Communication Skills

Design and implement extracurricular activities and workshops focused on developing leadership and communication skills among young girls, ensuring they emerge as confident leaders and advocates within the mathematical community and beyond.

2 Admission Criteria for BS Mathematics

As per approved Admission Policy RWU notified vide Notification No. RWU/VC/01/341; dated: 10th Mar, 2023.

3 Division and Distribution of Courses for

i) **BS Mathematics with Computer Science**

ii) **BS Mathematics with Finance**

Sr. #	Categories	No. of Courses	Credit Hours
1	General Education Courses	13	32
2	Major Courses	24	72
3	Interdisciplinary / Allied Courses	5	15
4	Minor Credit hours	04	12
5	Field Experience / Internship	01	3
6	Capstone Project	01	3
7	Mandatory Courses (Understanding of Holy Quran/ Ethics)	02	2

- Total Credit Hours 139
- Duration 4 Years
- Semester Duration 16 - 18 Weeks
- Semesters 8
- Course Load Per Semester 15 - 18 Credit Hours

4 Scheme of Studies for BS Mathematics with one Minor (Regular Batch)

The BS Mathematics program with a single major and one minor is focused on one disciplinary specialization and one secondary but supporting concentration.

Semester	Course Code	Course Title	Course Type	Pre-Requisite	Credit Hours
First	MTH-121	Calculus-I	Major	Nil	3
	CS-108	Introduction to Programming	Interdisciplinary	Nil	2
	CS-108L	Introduction to Programming (Lab)	Interdisciplinary	Nil	1
	MTH-110	Quantitative Reasoning-I	General Education	Nil	3
	XXX-XXX	Natural Science	General Education	Nil	2
	XXX-XXXL	Natural Science (Lab)	General Education	Nil	1
	ENG-110	Functional English	General Education	Nil	3
	CS-107	Application of Information and Communication Technologies	General Education	Nil	2
	CS-107L	Application of Information and Communication Technologies (Lab)	General Education	Nil	1
	Total				18
Second	ENG-111	Expository Writing	General Education	Nil	3
	PAK-104	Pakistan Studies	General Education	Nil	2
	STA-112	Quantitative Reasoning-II	General Education	Nil	3
	MTH-208	Discrete Mathematics	Major	Nil	3
	XXX-XXX	Arts and Humanities	General Education	Nil	2
	MTH-122	Calculus-II	Major	MTH-121	3
	UHQ-101/ ETH-103	Understanding of Holy Quran-I/ Ethics-I	Mandatory	Nil	1
	Total				17
Third	XXX-XXX	Social Science	General Education	Nil	2
	ISL-101/ ETH-101	Islamic Studies/ Ethics	General Education	Nil	2
	PAK-103	Ideology and Constitution of Pakistan	General Education	Nil	2
	MTH-311	Linear Algebra	Major	Nil	3

	MTH-201	Calculus-III	Major	MTH-122	3
	MTH-209	Elementary Differential Equations	Major	Nil	3
	STA-XXX	Statistics and Probability	Interdisciplinary	Nil	3
	Total				18
Fourth	MGT-108	Entrepreneurship	General Education	Nil	2
	MTH-211	Abstract Algebra	Major,	Nil	3
	MTH-212	Numerical Methods	Major	Nil	3
	MTH-213	Data Structure and Algorithms	Major	Nil	3
	MTH-312	Ordinary Differential Equations	Major	Nil	3
	CCE-497	Civic and Community Engagement	General Education	Nil	2
	UHQ-102/ ETH-104	Understanding of Holy Quran-II/ Ethics-II	Mandatory	Nil	1
	Total				17
Fifth	MTH-314	Real Analysis-I	Major	Nil	3
	MTH-305	Topology	Major	Nil	3
	MTH-309	Partial Differential Equations	Major	Nil	3
	CS-110	Advanced Programming	Interdisciplinary	Nil	2
	CS-110L	Advanced Programming (Lab)	Interdisciplinary	Nil	1
	PHY-104	Introduction to Mechanics	Interdisciplinary	Nil	2
	PHY-104L	Introduction to Mechanics (Lab)	Interdisciplinary	Nil	1
	XXX-XXX	Minor-I	Minor	Nil	3
	Total				18
Sixth	MTH-315	Real Analysis-II	Major	Real Analysis-I	3
	MTH-313	Complex Analysis	Major	Nil	3
	XXX-XXX	Elective-I	Major	Nil	3
	CS-109	Introduction to Machine Learning	Interdisciplinary	Nil	2
	CS-109L	Introduction to Machine Learning (Lab)	Interdisciplinary	Nil	1
	MTH-203	Classical Mechanics	Major	Nil	3
	XXX-XXX	Minor-II	Minor	Nil	3
	Total				18
Seventh	MTH-429	Differential Geometry	Major	Nil	3
	XXX-XXX	Elective-II	Major	Nil	3
	XXX-XXX	Elective-III	Major	Nil	3
	XXX-XXX	Elective-IV	Major	Nil	3
	INT-499	Internship	Mandatory	Nil	3

	XXX-XXX	Minor-III	Minor	Nil	3
	Total				18
Eighth	XXX-XXX	Elective-V	Major	Nil	3
	XXX-XXX	Elective-VI	Major	Nil	3
	XXX-XXX	Elective-VII	Major	Nil	3
	CP-498	Capstone Project	Mandatory	Nil	3
	XXX-XXX	Minor-IV	Minor	Nil	3
	Total				15
Total					139

5 List of Major Courses

Sr. No.	Course Code	Course Title	Pre-Requisite	Credit Hours
1.	MTH-121	Calculus-I	Nil	3
2.	MTH-122	Calculus-II	Calculus-I	3
3.	MTH-201	Calculus-III	Calculus-II	3
4.	MTH-203	Classical Mechanics	Nil	3
5.	MTH-208	Discrete Mathematics	Nil	3
6.	MTH-209	Elementary Differential Equations	Nil	3
7.	MTH-303	Differential Geometry-I	Nil	3
8.	MTH-211	Abstract Algebra	Nil	3
9.	MTH-305	Topology	Nil	3
10.	MTH-309	Partial Differential Equations	Nil	3
11.	MTH-311	Linear Algebra	Nil	3
12.	MTH-312	Ordinary Differential Equations	Nil	3
13.	MTH-313	Complex Analysis	Nil	3
14.	MTH-212	Numerical Methods	Nil	3
15.	MTH-314	Real Analysis-I	Nil	3
16.	MTH-315	Real Analysis-II	Real Analysis-I	3
17.	MTH-213	Data Structure and Algorithms	Nil	3

6 Course Outlines for Major Courses

Calculus-I

BS-Mathematics

Course Code: MTH-121

Credit Hours: 03

Pre-requisite: Nil

Objectives

This first course in calculus introduces the essential concepts of limits, continuity, differentiation, and integration for functions of one variable, forming a base for further study in mathematics.

Learning Outcomes

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

- Understand function behaviour by means of graphs
- Apply differentiation and integration techniques to solve real-world problems.
- Analyze the behavior of functions using graphical and analytical methods.

Course Outline

Unit 1. Preliminaries

Solving linear and quadratic equations, division of polynomials, synthetic division, roots of polynomials. Viète relations Descartes rule of signs. Solving linear inequalities, linear and nonlinear inequalities with absolute value. Domain and range of a function, examples polynomial, rational, piecewise defined functions, absolute value functions. Sum, product, quotient and compositions. Graphs of functions, linear, quadratic, piecewise functions. Equation of a straight-line slope and intercept of a line, parallel and perpendicular lines. Solution of the system of linear equations. Nonlinear systems, at least one quadratic equation.

Unit 2. Limits and Continuity

Limit of a function, graphical approach, properties & theorems of limits. Limits of polynomials, rational and transcendental functions. Limits at infinity, infinite limits, one-sided limits. Continuity.

Unit 3. Derivatives

The derivative as a rate of change. Derivatives Rules. Derivatives of trigonometric, polynomials, rational, exponential and logarithmic functions. Chain Rule. Implicit differentiation. Higher Derivatives. Leibnitz theorem.

Unit 4. Applications of Derivatives

Increasing and decreasing functions, first derivative test, convexity and point of inflection. The second derivative test. Inverse of functions and their derivatives.

Unit 5. Integration

Riemann sums and the definite integral. Properties of integral. The fundamental theorem of calculus. The substitution rules.

Recommended Books/Reference Material

1. Anton, H. Bivens, I.C., and Davis, S. (2021). *Calculus*. John Wiley and Sons.
2. Ayres, F., and Mendelson, E. (2009). *Calculus*. Schaum's Outlines.
3. Hughes-Hallett, D., Gleason, A.M., and McCallum, W.G. (2020). *Calculus: Single and Multivariable*. John Wiley and Sons.
4. Stewart, J., Clegg, D.K., and Watson, S. (2020). *Calculus: Early Transcendentals*. Cengage Learning.
5. Thomas, G. B., Finney, R. L., Weir, M. D., & Giordano, F. R. (2003). *Thomas' calculus*. Reading: Addison-Wesley.

Calculus-II

BS-Mathematics

Course Code: MTH-122

Credit Hours: 03

Pre-requisite: Calculus-I

Objectives

This is the second course of Calculus. As a continuation of Calculus-I, it focuses on techniques of integration and applications of integrals. The course also aims at introducing the students infinite series, parametric curves and polar coordinates.

Learning Outcomes

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

- Understand the techniques of integration and its applications in calculating areas and volumes
- Apply integration techniques to solve real-world problems.
- Analyze convergence of improper integrals and infinite series.

Learning Outcomes

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

- Understand the techniques of integration and its applications in calculating areas and volumes.
- Apply integration techniques to solve real-world problems.
- Analyze convergence of improper integrals and infinite series.

Course Outline

Unit 1. Techniques of Integration

Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions.. Integration by parts, substitution, and integration by partial fractions. Improper integrals. Gamma functions.

Unit 2. Applications of Integrals

Area between curves, average value. Volume. Area of a surface of revolution. Arc length. Applications to economics, physics, engineering and biology.

Unit 3. Infinite Series

Sequences and series. Convergence and absolute convergence. Divergence test, integral test, P-series test, comparison test, limit comparison test, alternating series test, ratio test, root test. Power series, convergence of power series.

Unit 4. Conic Sections and Parametrized Curves

Parabola, ellipse and hyperbola. Curves defined by parametric equations. Calculus with parametric curves. Tangent, areas, arc length.

Unit 5. Polar Coordinates

Polar Curves. Tangents to polar curves. Areas and arc length in polar coordinates.

Recommended Books/Reference material

1. Anton, H., Bivens, I. C., Davis, S. (2022). *Calculus: Single Variable*. United States: Wiley.
2. Fehribach, J. D. (2023). *Sequences and Series in Calculus*. Germany: De Gruyter.
3. HughesHallett, D., Gleason, A. M., Mccallum, W. G. (2020). *Calculus: Single and Multivariable*. United Kingdom: Wiley.
4. Stewart, J., Clegg, D.K., and Watson, S. (2020). *Calculus: Early Transcendentals*. Cengage Learning.
5. Thomas, G. B., Finney, R. L., Weir, M. D., & Giordano, F. R. (2003). *Thomas' calculus*. Reading: Addison-Wesley.

Calculus-III

BS-Mathematics

Course Code: MTH-201

Credit Hours: 03

Pre-requisite: Calculus-II

Objectives

In this third course of Calculus a student applies the concepts learned in the first two courses. In this course students learn about vector calculus, the calculus of multivariable functions and double and triple integrals along with their applications.

Learning Outcomes

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

- Analyze multivariable functions and compute partial derivatives.
- Apply multiple integrals in solving problems related to volume and surface areas in three dimensional space.
- Understand vector calculus and its applications in fields under interest.

Course Outline

Unit 1. Vectors and Analytic Geometry in Space

Coordinate system. Rectangular, cylindrical and spherical coordinates. The dot product, the cross product. Equations of lines and planes. Quadric surfaces.

Unit 2. Vector-Valued Functions

Vector-valued functions and space curves. Derivatives and integrals of vector valued functions. Arc length. Curvature. Normal and binormal vectors.

Unit 3. Multivariable Functions and Partial Derivatives

Functions of several variables. Limits and continuity. Partial derivatives. Composition and chain rule. Directional derivatives and the gradient vector. Implicit function theorem for several variables. Maximum and minimum values. Optimization problems. Lagrange multipliers.

Unit 4. Multiple Integrals

Double integrals over rectangular domains and iterated integrals. Non-rectangular domains. Double integrals in polar coordinates. Triple integrals in rectangular, cylindrical and spherical coordinates. Applications of double and triple integrals. Change of variables in multiple integrals.

Unit 5. Vector Calculus

Vector fields. Line integrals. Green's theorem. Curl and divergence. Surface integrals over scalar and vector fields. Divergence theorem. Stokes' theorem.

Recommended Books/Reference Material:

1. Anton, H., Bivens, I. C., Davis, S. (2022). *Calculus: Single Variable*. United States: Wiley.
2. Helfgott, M. (2023). *Calculus for the Natural Sciences*. United States: Society for Industrial and Applied Mathematics.
3. HughesHallett, D., Gleason, A. M., Mccallum, W. G. (2020). *Calculus: Single and Multivariable*. United Kingdom: Wiley.
4. Stewart, J., Clegg, D.K., and Watson, S. (2020). *Calculus: Early Transcendentals*. Cengage Learning.
5. Thomas, G. B., Finney, R. L., Weir, M. D., & Giordano, F. R. (2003). *Thomas' calculus*. Reading: Addison-Wesley.

Classical Mechanics

BS-Mathematics

Course Code: MTH-203

Course Type: Major

Credit Hours: 3

Pre-requisite: Nil

Objectives

The course offers Newton's laws of motion and their applications to mechanical systems.

The Lagrangian and Hamiltonian mechanics to solve advanced dynamics problems.

The course focus to analyze the conservation of energy and momentum in physical systems.

Learning Outcomes

By the end of this course, the students will be able to

- Understand Newton's laws of motion and their applications to mechanical systems.
- Apply Lagrangian and Hamiltonian mechanics to solve advanced dynamics problems.
- Analyze the conservation of energy and momentum in physical systems.

Course Outlines

Unit 1. Kinematics

Rectilinear motion, uniform and uniformly accelerated rectilinear motion. Tangential and normal components, radial and transverse components, projectile motion.

Unit 2. Kinetics

Work, power, kinetic and potential energy. Conservative force field, conservation of energy. Impulse, torque, conservation of linear and angular momentum, non-conservative force. Rotating axes, Rate of change of vector; Application to motion relative to rotating earth, Newton's laws of motion; Work, energy and power; conservative forces (N.A.S.C for a force to be conservative), potential energy.

Unit 3. Simple Harmonic Motion and Central Forces

The simple harmonic motion. The damped harmonic oscillator. Central forces fields.
Equations of motion.

Unit 4. Planetary Motion of Rigid Bodies

Kepler's law of planetary motion. Motion in an inverse square field. Introduction to rigid and elastic bodies, degree of freedom, Euler's and Chasles's theorem, Rotation of a rigid body about a fixed axis. Moments and products of inertia, parallel and perpendicular axis theorem.

Unit 5. Motion of Rigid Bodies in Three Dimensions

General motion of rigid bodies in space. Momental ellipsoid and equi-momental systems. Angular momentum vector and rotational kinetic energy. Principal axis and principal moments of inertia. Force free motion, free rotation of a rigid body with an axis of symmetry and with three different principal moments. Euler's angles, motion of a spinning top, sleeping top . Systems of Particles

Generalized coordinates, D Alembert's principle, Lagrange's equation of motion, Applications to theory of small oscillation. Techniques of Lagrangian and Hamiltonian mechanics for solving the dynamic problems

Recommended Books/Reference Material

1. Deshmukh, P. C. (2019). *Foundations of Classical Mechanics*. India: Cambridge University Press
2. Goldstein, H. (2011). *Classical Mechanics*. India: Pearson.
3. Helliwell, T. M., Sahakian, V. V. (2021). *Modern Classical Mechanics*. United Kingdom: Cambridge University Press.
4. Kamberaj, H. (2021). *Classical Mechanics*. Germany: De Gruyter.
5. Philpot, T. A., Thomas, J. S. (2020). *Mechanics of Materials: An Integrated Learning System*. United Kingdom: Wiley.

Discrete Mathematics

BS-Mathematics

Course Code: MTH-208

Credit Hours: 03

Pre-requisite: Nil

Objectives:

Discrete Mathematics is study of distinct, un-related topics of mathematics; it embraces topics from early stages of mathematical development and recent additions to the discipline as well. The present course restricts only to counting methods, relations and graphs. The objective of the course is to inculcate in the students the skills that are necessary for decision-making in non-continuous situations

Learning Outcomes:

By the end of this course, students will be able to

- Understand the principles of combinatorics, set theory, and graph theory.
- Apply discrete mathematical techniques to solve problems in computer science and
- cryptography.
- Analyze logical structures and use them in algorithmic problem-solving.

Course Outline

Unit 1. Counting methods

Basic methods: product, inclusion-exclusion formulae. Permutation and Combinations. Recurrence relations and their solutions. Generating functions. Double counting and its application. Pigeonhole principle and its application

Unit 2. Predicates and quantifiers

Introduction to Logics. Propositions and Predicates. Logical Operator. Propositional Equivalence. Predicates and Quantifiers

Unit 3. Methods of proofs and algorithm

Rules of Inference. Methods of proofs. Direct Proofs, proofs by contradiction. Algorithms, Searching Algorithms and Sorting Algorithms

Unit 4. Graphs

Graphs. Graph Terminologies and some special types of graphs. Representing Graphs. Connectivity of Graphs. Shortest Path Algorithm. Algebraic methods: the incidence matrix
Trees

Unit 5. Induction, recursion and relations

Mathematical Induction concepts. examples of induction. Recursion, method of recursion. Binary relations. n-array relations. composition of relations and inverse relation.

Recommended books/reference material:

1. S. Susanna. Discrete Mathematics with Applications 5th Edition, 2018.
2. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill, New York, (7thedition), 2012.
3. Kenneth A. Ross and Charles R. Wright, Discrete Mathematics, Prentice Hall, Englewood Cliffs, NJ, USA., 2018.
4. G. O'Regan. Guide to Discrete Mathematics: An Accessible Introduction to the History, Theory, Logic and Applications. 2nd Edition, Kindle Edition, 2021

Elementary Differential Equations

BS-Mathematics

Course Code: MTH-209

Credit Hours: 03
Pre-requisite: Nil

Objectives

Students must know about the formulation and classification of differential equations along with the existence and uniqueness of solutions. To improve students' skills in solving initial value and boundary value problems. Students must understand how to solve first and second order linear homogeneous and non-homogeneous differential equations and can solve differential equations using power series methods.

Learning Outcomes

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

- Formulate and solve first (linear and non-linear) and higher order differential equations.
- Apply differential equations to model real-world systems in applied sciences.
- Analyze the behavior of solutions.

Course Outline

Unit 1. Preliminaries

Introduction and formulation. Classification of differential equations. Existence and uniqueness of solutions. Introduction of initial value and boundary value problems.

Unit 2. First Order Ordinary Differential Equations

Separable variables. Exact and non-exact differential equation. Homogeneous and nonhomogeneous differential equations. Linear and nonlinear differential equations. Bernoulli's differential equation, Ricaati equation, Clairaut equation.

Unit 3. Second Order Differential Equations

Ricaati type. Clairaut equation. Solution of 2nd order homogeneous and non-homogeneous ODEs.

Unit 4. Higher Order Differential Equations

Solution of higher order homogeneous and non-homogeneous ODEs. Undetermined coefficient method. Method of variation of parameter. Solution of Cauchy-Euler equation.

Unit 5. Series Solutions

Power series method of ODEs, ordinary and singular points, existence of power series solution. Frobenius theorem, existence of Frobenius series solutions, Frobenius method.

Recommended Books/Reference Material

1. Boyce, W. E., DiPrima, R. C., Meade, D. B. (2022). *Elementary Differential Equations and Boundary Value Problems*. United States: Wiley.
2. Ross, S. (2021). *Introduction to Ordinary Differential Equations*. John Wiley & Sons.
3. Tu, H. T., Phan, T. T., & Nguyen, K. P. (2022). *Modeling information diffusion in social networks with ordinary linear differential equations*. Information Sciences, 593, 614-636.
4. Zill, D. G. (2023). *Differential Equations with Boundary-Value Problems*. United States: Cengage Learning.

Differential Geometry

BS-Mathematics

Course Code: MTH-429

Credit Hours: 03

Pre-requisite: Nil

Objectives

Main objective of this course is to enhance the capability of students to learn geometry in the sense of calculus, topological point of view. They will be able to understand and perform computation related to curves, surfaces and their properties.

Understand and compute different forms of surfaces. differential geometry is going to convert the non-linear system into a linear system.

Learning Outcomes

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

- Understand the concepts of curves, surfaces, and their geometric properties.
- Apply differential techniques to analyze the curvature, torsion, tangent, normal, and binormal curves.
- Analyze the applications of differential geometry in applied sciences.

Course Outline

Unit 1. Curve Theory and Planes

Motivation and applications of differential geometry, index notation and summation convention, introduction to curves theory, regular and natural representation/reparameterization and arc length in curve theory, space curves, arc length, tangent, normal and binormal, osculating, normal and rectifying planes

Unit 2. Frenet- Serret Apparatus

The Frenet- Serret theorem, intrinsic equations, fundamental existence and uniqueness theorem, canonical representation of a curve, involutes and evolutes

Unit 3. Surfaces Theory of Contact

Osculating curves and surfaces, regular parametric representations of a surface, coordinate patch, definition of a simple surface, tangent plane and normal line.

Unit 4. Forms

The first fundamental and second fundamental forms and its applications.

Unit 5. Curvatures

Principal Gaussian, mean, geodesic and normal curvatures, continuity and compactness, minimizers and maximizers, uniform continuity, continuity and connectedness, intermediate value theorem, monotone functions and discontinuities, mean value theorem, L'Hopital value.

Recommended Books/Reference Material

1. Eisenhart, L. P. (2015). *Introduction to differential geometry (Vol. 2227)*. Princeton University Press.
2. Hilbert, D., & Cohn-Vossen, S. (2021). *Geometry and the imagination*. American Mathematical Soc.
3. Kreyszig, E. (2013). *Differential geometry*: Courier Corporation.
4. Kühnel, W. (2006). *Differential Geometry: Curves, Surfaces, Manifolds*, American Mathematical Society.
5. Prasolov, V. V. (2022), *Differential geometry*, Springer International Publishing

Abstract Algebra

BS-Mathematics

Course Code: MTH-211

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course introduces basic concepts of groups and their homomorphism. The main objective of this course is to prepare students for courses which require a good background in group theory like Rings and Modules, Linear Algebra, Group Representation and Galois Theory etc.

Learning Outcomes

- Students must understand the concepts of groups, rings and fields.

- Students can understand the pure concepts of mathematics.
- Students must adopt the logical way of mathematics.

Course Outline

Unit 1. Groups

Basic ideas related to set theory, definition and examples of groups, order of group, order of an element, abelian groups. Sub group, subgroup generated by a set. Cyclic group and their fundamental theorems.

Unit 2. Complexes and Co-sets of a Group

Complexes and co-sets decomposition of groups, index of subgroup in a group. Lagrange's theorem and its application. Normalized and centralizer in a group.

Unit 3. Permutation Groups

Definition of permutation group, examples. The cyclic decomposition of a permutation group. Cayley's Theorem. Direct product of two groups. Double co-sets.

Unit 4. Normal Subgroups

Normal subgroup and quotient groups.

Unit 5. Group Homomorphism

Definition of homomorphism, endomorphism and automorphism. Isomorphism theorems of groups and their related results, Cauchy's theorem for abelian groups. Cauchy's theorem for general groups.

Unit 6. Rings and Fields

Definition, basic concepts of rings, subrings . Fields and examples of fields.

Recommended Books/Reference Material

1. Fraleigh, J.B. (2002). *A First Course in Abstract Algebra*. Addison-Wesley Publishing Company.
2. Hall, M. (2018). *The Theory of Groups*. Courier Dover Publications.
3. Kaplansky, I. (2018). *Infinite Abelian Groups*. Courier Dover Publications.
4. McKenzie, R.N., McNulty, G.F., and Taylor, W.F. (2018). *Algebras, Lattices, Varieties*. American Mathematical Society.
5. Xue, Z. (2022). *Group Theory and Ring Theory*. IOP Publishing.
6. Gallian, J. A. (2017). *Contemporary abstract algebra*. Cengage Learning.

Topology

BS-Mathematics

Course Code: MTH-305

Credit Hours: 03

Pre-requisite: Nil

Objectives

The aim of this course is to introduce the students to metric spaces and topological spaces. After completion of this course, they would be familiar with separation axioms, compactness and connectedness. They would be able to determine whether a function defined on a metric or topological space is continuous or not and what homeomorphisms are.

Learning Outcomes

- Understand fundamental concepts of topology and explore basis, neighborhood bases, and countability axioms.
- Analyze compactness, compact spaces and explore connectivity and disconnectedness.
- Analyze continuous functions, homeomorphism, and weak topologies in various topological spaces, including finite product spaces.
- Explore separation axioms, regular spaces, and completely regular spaces, understanding their properties and significance.

Course Outline

Unit 1. Topological Spaces

Sets and relation, equivalence relation, functions, topological spaces, open and closed sets, subspaces, neighborhoods, dense sets, limit points, closure of a set interior, exterior and boundary of a set, induced topology and quotient topology, cofinite topology.

Unit 2. Bases and Sub-bases

Base and sub bases, neighborhood bases, separable spaces, Lindelöf spaces, continuous functions and homeomorphism, weak topologies and finite product spaces.

Unit 3. Separation Axioms

Separation axioms, completely regular spaces and normal spaces.

Unit 4. Compact Spaces

Compact topological spaces, countable compact spaces and sequentially compact spaces.

Unit 5. Connectedness

Connected spaces, disconnected spaces, regular spaces and totally disconnected spaces components of topological spaces.

Recommended Books/Reference Material

1. Edelsbrunner, H., and Harer, J.L. (2022). *Computational Topology: An Introduction*. American Mathematical Society.
2. Kelley, J.L. (2017). *General Topology*. Courier Dover Publications.
3. Lefschetz, S. (2015). *Introduction to Topology*. Princeton University Press.
4. Massey, W.S. (2019). *A Basic Course in Algebraic Topology*. Springer.
5. Sierpinski, W. (2020). *General Topology*. Courier Dover Publications.

Partial Differential Equations

BS-Mathematics

Course Code: MTH-309

Credit Hours: 03

Pre-requisite: Nil

Objectives

Partial differential equations (PDEs) are the heart of applied mathematics and of many other scientific disciplines. The course aims at developing understanding about fundamental concepts of the identification and classification of different types of the PDEs and how they arise in multiple applications. Special emphasis would be on wave, heat and Laplace equations.

Learning Outcomes

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

- Develop PDEs to model physical phenomena.
- Solve partial differential equations using methods of characteristics, separation of variables and integral transforms.
- Apply transforms to solve partial differential equations.
- Analyze the solutions of initial and boundary value problems and their stability.

Course Outline

Unit 1. Basic Concepts of Partial Differential Equations

Definition, order and degree of PDEs. Homogeneous and non-homogeneous PDE. Auxiliary conditions. Formulation of PDEs and their solutions. Solutions of first order PDEs. The Cauchy's problem for quasilinear first order PDEs. First order nonlinear equations. Special types of first order equations. Mathematical models: The classical equations such as, vibrating string, vibrating membrane, conduction of heat in solids.

Unit 2. Second Order Partial Differential

Classifications of second order partial differential equation, Well-Posed problems. Mathematical problems. Superposition. Method of separation of variables. D'Alembert's solution of the wave equation. Canonical form for hyperbolic equations. Canonical form for parabolic equations. Canonical form elliptic equation.

Unit 3. Partial Differential Equations Arising in Physical Problems

Wave Equation. Heat Equation. Laplace Equation.

Unit 4. PDE in Plane, Polar, Cylindrical and Spherical Coordinates

Wave equation in polar, cylindrical coordinates. Heat equation in cylindrical polar coordinates. Laplace equation in polar, cylindrical and spherical coordinates.

Unit 5. Laplace, Fourier, Hankel Transform

Solution of PDEs using Laplace transform. Fourier transform and their applications.

Recommended Books/Reference Material

1. Borthwick, D. (2017). *Introduction to partial differential equations*. Springer.
2. Evans, L. C. (2022). *Partial differential equations (Vol. 19)*. American Mathematical Society.
3. Rao, K. S. (2010). *Introduction to partial differential equations*. PHI Learning Pvt. Ltd.
4. Zill, D. G. (2020). *Advanced engineering mathematics*. Jones & Bartlett Learning.

Linear Algebra

BS-Mathematics

Course Code: MTH-311

Credit Hours: 03

Pre-requisite: Nil

Objectives

Linear algebra is the study of vector spaces and linear transformations. The main objective of this course is to help students learn in a rigorous manner, the tools, and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences and develop mathematical skills needed to apply these to the problems arising within their field of study and to various real-world problems.

Learning Outcomes

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

- Understand the theory of matrices, vector spaces and linear transformations.
- Apply linear algebra techniques to solve systems of linear equations.
- Analyze eigenvalues, eigenvectors, and their applications in various fields, including machine learning.

Course Outline

Unit 1. Matrices and its Solutions

Matrices. Operation on matrices. Echelon and reduced echelon form. Inverse linear system. Gaussian elimination. Determinants of a matrix, computing higher order determinants.

Unit 2. Vector Space

Vector spaces, subspaces, linear combination and spanning set. Linear dependence and independence. Finite dimensional vector spaces, bases and dimension of a vector space. Operations on subspaces, intersections and sums.

Unit 3. Transformations

Linear transformations, kernel and image of a linear transformation. Isomorphism and composition. Matrix of a linear map, change of basis, invariant subspaces and direct sums.

Unit 4. Eigen Values and Eigen Vectors

Eigenvalues, Eigen vectors, diagonalization, and orthogonal diagonalization.

Unit 5. Inner Product Spaces

Inner product spaces, norms and Cauchy inequality.

Recommended Books/Reference Material

1. Aggarwal, C.C., Aggarwal, L.F., and Lagerstrom-Fife. (2020). *Linear Algebra and Optimization for Machine Learning*. Springer International Publishing.
2. Hill, R. O. (2014). *Elementary linear algebra*. Academic Press.
3. Strang, G. (2022). *Introduction to Linear Algebra*. Wellesley-Cambridge Press.
4. Shapiro, H. (2015). *Linear algebra and matrices*. AMS, Providence, Rhode Island.
5. W. K. Nicholson, (2021), *Linear Algebra with Applications*, (Lyryx Learning Inc.

Ordinary Differential Equations

BS-Mathematics

Course Code: MTH-312

Credit Hours: 03

Pre-requisite: Nil

Objectives

To improve students' skills in solving initial value and boundary value problems. Students must understand how to solve SL System, Laplace transformation and Fourier series and learn how to solve Bessel and Legendre differential equations.

Learning Outcomes

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

- Understand SL-boundary value problems and series solution methods.
- Apply differential equations to model dynamic systems.
- Analyze the behavior of solutions using phase plane analysis.

Course Outline

Unit 1. Strum-Liouville (SL) System

Some properties of SL equations. Regular, periodic and singular SL systems and its applications. Self-adjoint operators. Eigenvalues and Eigen functions of the singular SL system.

Unit 2. Laplace Transformation

Laplace transform of a function. First shifting theorem for Laplace transform. Unit step function. Inverse Laplace transforms. Properties of convolution. Convolution theorem. System of differential equations.

Unit 3. Fourier Series

Fourier series. Orthogonal polynomials.

Unit 4. Bessel Functions

Bessel functions. Solution of Bessel's differential equation. Modified Bessel's differential equation. Equations reducible to modified Bessel's equation.

Unit 5. Legendre Differential Equation

Solution of Legendre's differential equation. Associated Legendre's differential equation. Solution of associated Legendre's differential equation.

Recommended Books/Reference Material

1. Borzì, A. (2020). *Modeling with ordinary differential equations: a comprehensive approach*. CRC Press.
2. Ross, S. (2021). *Introduction to Ordinary Differential Equations*. John Wiley & Sons.
3. Wasow, W. (2018). *Asymptotic Expansions for Ordinary Differential Equations*. Courier Dover Publications.

4. Zill, D. G. (2016). *Differential equations with boundary-value problems*. Cengage Learning.

Complex Analysis

BS-Mathematics

Course Code: MTH-313

Credit Hours: 03

Pre-requisite: Nil

Objectives

Complex variables are an important area from a purely mathematical point of view, as well as a powerful tool for solving a wide variety of applied problems. It is finding its applications in many mathematical disciplines, including in particular real analysis, differential equations, algebra and topology. This course develops the theory of functions of a complex variable, emphasizing their geometric properties and some applications. It also treats the traditional theorems, algorithms, and applications of complex analysis. These include, finding of complex roots for polynomial equations and complex integration, residue theorem and its applications.

Learning Outcomes

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

- Understand the properties of complex functions and analytic continuation.
- Apply complex integration techniques to solve real-world problems.
- Understand concepts of complex sequences and infinite series and the Laurent series, residues, and the residue theorem and its applications .
- Analyze the applications of complex analysis in various fields.

Course Outline

Unit 1. Introduction to Complex Numbers

Complex numbers, Sums and products, basic algebraic properties. Vectors and moduli. Complex conjugates. Exponential form. Products and powers in exponential form. Arguments of products and quotients. Roots of complex numbers. Regions in the complex plane.

Unit 2. Analytic Functions

Analytic functions. Functions of a complex variable. Mappings. Mappings by the exponential function, limits, theorems on limits. Continuity. Derivatives. Cauchy–Riemann equations. Sufficient conditions for differentiability. Polar coordinates. Analytic functions. Harmonic functions.

Unit 3. Exponential and Logarithmic Functions

Elementary functions: The exponential function. Logarithmic function. Branches and derivatives of logarithms. Complex exponents. Trigonometric functions. Hyperbolic functions.

Unit 4. Derivatives and Integrals of Complex Valued Functions

Integrals. Derivatives of functions. Definite integrals. Contours. Contour integrals, Branch cuts. Upper bounds for moduli of contour integrals. Cauchy–Goursat Theorem. Simply connected domains. Multiply connected domains, Cauchy integral formula. Liouville’s theorem and the fundamental theorem of algebra. Maximum modulus principle.

Unit 5. Series and Sequences

Series, Convergence of sequences. Convergence of series. Taylor series. Laurent series. Absolute and uniform convergence of power series. Integration and differentiation of power series. Uniqueness of series representations. Multiplication and division of power series.

Unit 6. Residues and Poles

Isolated Singular Points, Residues, Cauchy’s Residue Theorem, Residue at Infinity, The Three Types of Isolated Singular Points, Residues at Poles, Zeros of Analytic Functions, Zeros and Poles, Behavior of Functions Near Isolated Singular Points.

Recommended Books/Reference Material

1. Brown, J. W., & Churchill, R. V. (2009). *Complex variables and applications*. McGraw-Hill.
2. Boas, R. P. (2020). *Invitation to Complex Analysis*. American Mathematical Society.
3. Lvovski, S. (2020). *Principles of Complex Analysis*. Springer.
4. Needham, T. (2023). *Visual Complex Analysis*. Oxford University Press.
5. Zill, D., & Shanahan, P. (2009). *A first course in complex analysis with applications*. Jones & Bartlett Learning.

Numerical Methods

BS-Mathematics

Course Code: MTH-212

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is designed to teach the students about the numerical methods and their theoretical bases. The course aims at inculcating in the students the skill to apply various techniques in numerical analysis, understand and do calculations about errors that can occur in numerical methods and understand and be able to use the basics of matrix analysis.

Learning Outcomes

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

- Understand the basic techniques for numerical approximation.
- Apply numerical methods to solve algebraic, transcendental, and differential equations.
- Analyze the stability and convergence of numerical algorithms.

Course Outline

Unit 1. Number System Computer

Arithmetic and errors. Binary, decimal, octal & hexadecimal systems and their conversions. Computer arithmetic. Floating point arithmetic. Significant digits. Precision and accuracy. Absolute, relative, and percentage errors. Order of approximation.

Unit 2. Methods for the Solution of Non-linear Equations

Bisection method. Regula Falsi method. Secant method. Newton Raphson method. Functional iteration or fixed-point iterative technique. Error analysis of iterative methods.

Lab Work: In MATLAB / Mathematica / Python..

Unit 3. Interpolation

Linear operators interpolation with unequally spaced arguments, Lagrange interpolation formula, Newton divided difference interpolation formula, uniqueness of interpolation polynomial, error analysis of interpolation polynomial). Interpolation with equally spaced arguments . Newton-Gregory, forward difference interpolation formula, Newton-Gregory backward, Difference interpolation formula, stirling, Bessels, Gauss forward/backward, Laplace, Everett's central difference interpolation formulae, Aitken's interpolation scheme. Lab Work: In MATLAB / Mathematica / Python..

Unit 4. Numerical Solution of a System of Linear Equations

Direct methods (Gaussian elimination method, Gauss-Jordan method, matrix. Inversion method, LU-decomposition ,Doolittle, Crouts, and Cholesky methods. Iterative methods (Jacobi's method, Gauss-Seidel method, SOR method).

Lab Work: In MATLAB / Mathematica / Python.

Unit 5. Dominant, Intermediate and Smallest Eigen Pairs

Power and Rayleigh quotient method for finding. The dominant eigenvalue and corresponding eigenvector. The intermediate eigenvalue and corresponding eigenvector. The smallest eigenvalue and corresponding eigenvector.

Recommended Books/Reference Material

1. Burden, R. L., Faires, J.D., and Burden, A.M. (2015). *Numerical Analysis*. Cengage Learning.
2. Conte, S. D., and De Boor, C. (2017). *Elementary Numerical Analysis: An Algorithmic Approach*. Society for Industrial and Applied Mathematics.
3. Greenspan, D. (2018). *Numerical Analysis*. CRC Press.
4. Leader, J. J. (2022). *Numerical Analysis and Scientific Computation*. CRC Press.
5. Linz, P. (2020). *Theoretical Numerical Analysis*. Courier Dover Publications.
6. Rao, K. S. (2018). *Numerical Methods for Scientists and Engineers*. India: Prentice Hall India Pvt., Limited.

Real Analysis-I

BS-Mathematics

Course Code: MTH-314

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to study the properties of real numbers and their applications in calculus. Apart from this the rigorous concepts of limits, continuity, and differentiability for real-valued functions, the convergence of sequences and series using real analysis techniques will be studied.

Course Outcomes

By the end of this course, the students will be able to,

- Study the properties of real numbers and their applications in calculus.
- Understand the rigorous concepts of limits, continuity, and differentiability for real-valued functions.
- Analyze the convergence of sequences and series using real analysis techniques.

Course Outlines

Unit 1. The Real Numbers System

The algebraic properties of $\mathbb{R}$, the order properties of $\mathbb{R}$, the completeness property of $\mathbb{R}$. Properties of the supremum and the infimum of a subset of $\mathbb{R}$. Intervals, Cluster points, Open and closed sets in $\mathbb{R}$.

Unit 2. Sequences

Sequences and their limits, limit theorems, Monotone sequences, subsequences and the Balzano-Weirstrass Theorem.

Unit 3. Limits and Continuity

Limits of functions, limit theorems. Some extensions of the limit concept, left hand and right hand limits. Continuous functions. Combinations of continuous functions. Continuous functions on intervals, boundedness theorem, maximum-minimum theorem, intermediate value theorem. Uniform continuity.

Unit 4. Differentiation

The derivative, the Rolle's theorem, the mean value theorems, Taylor's theorems with remainder after n terms.

Unit 5. Functions of Several Variables

Limit and Continuity of functions of several variables, partial derivatives, differentiable functions. Homogeneous functions, Euler's theorem, higher derivatives, Taylor's theorem.

Recommended Books

1. Bartle, R. G. and Sherbert, D. R. (2011). *Introduction to Real Analysis*, (4th ed.). John Wiley & Sons
2. Anton, H., Bivens, I. C., Devis, S. (2012). *Calculus*. 10th ed. Wiley
3. Rudin, W. (1995). *Principles of Real Analysis*. McGraw-Hill.

Real Analysis-II

BS-Mathematics

Course Code: MTH-315

Credit Hours: 03

Pre-requisite: Real Analysis-I

Objectives

The objective of this course is to study the tests for convergence of sequences of functions and learn theory of Riemann-Stieltjes integrals. , advanced real analysis techniques to study proper and improper integrals.

Course Outcomes

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

- Understand the tests for convergence of sequences of functions.
- Learn theory of Riemann-Stieltjes integrals.
- Apply advanced real analysis techniques to study proper and improper integrals.

Course Outline

Unit.1 Infinite Series-I

Review of sequences, definition of convergence of a series, the geometric series, the divergence test, the comparison tests, the ratio test, the root test.

Unit2 Infinite Series-II

Alternating series, the alternating series test, absolute and conditional convergence. Regrouping and re-arrangement of terms of a series, power series, radius of convergence, cauchy product of series.

Unit3. Uniform Convergence

Pointwise convergence, Uniform convergence of a sequence and a series, Weierstrass M-test. Properties of uniformly convergent series. Term by term differentiation and integration of a series. Application to power series. Taylor's series. Weierstrass Approximation Theorem.

Unit4. Integrability

Upper and lower sums, upper and lower integrals, the Riemann integral some examples of integrable and non-integrable functions, Riemann integrability criterion. Properties of Riemann integrals. The fundamental theorem of Calculus.

Unit 5. Improper Integrals

Classification of improper integrals. Definition of Convergence, examples, comparison tests, absolute and conditional convergence. First type of improper integrals, limit tests. Conditions for the convergence of integrals for $f(x)\sin x$. Second and Third types of integrals Mixed types, Gamma function, the principal value of an integral. Uniform convergence of integrals, Weierstrass M-test, properties of uniformly convergent integrals.

Recommended Books

1. Bartle, R. G. and Sherbet, D. R. (2011). *Introduction to Real Analysis (4th ed.)*. John Wiley Sons.
2. Rudin, W. (1995). *Principles of Real Analysis*. McGraw-Hill

Data Structure and Algorithms

BS-Mathematics

Course Code: MTH-213

Credit Hours: 03

Pre-requisite: Nil

Objectives

This is a fundamental course on algorithms based on asymptotic performance of algorithms. These are based on data structures like arrays, stacks, queues, and trees, recurrence relations and apply divide and conquer strategy. The concepts of graphs and trees and related algorithms are also included.

Learning Outcomes

By the end of this course, students will be able to

- Understand fundamental data structures like arrays, stacks, queues, and trees.
- Apply algorithmic techniques to solve sorting, searching, and optimization problems.
- Analyze the time and space complexity of algorithms for efficiency.

Course Outlines

Unit 1. Introduction

What is an algorithm?, History, Properties of algorithms, The growth of functions.

Unit2 Complexity of Algorithms

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

Unit3. Abstract Data Types (ADTs)

Array and Polynomial as an ADT, Sparse Matrices, and Representation of Arrays. Stack ADT: Linked lists and array implementations, Expressions, Postfix Notation, and Infix to postfix conversion. Recursive definition, Recursive algorithms, Divide-and-conquer algorithms, Recurrence relations. Methods for solving recurrences: Substitution method, Recursion tree method, Master method.

Unit4 Hashing

Hash Functions, Division, Overflow Handling, Chaining.

Unit5 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.

Unit6 Trees and Related Algorithms

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

Recommended Books

1. Adam B. Drozdek, *Data Structure and Algorithm in C++*, 4th edition, Cengage Learning, 4th edition, 2012.
2. Cormen, T. H., Leiserson, C. E. et al., *Introduction to Algorithms*, MIT Press, 4th edition, 2022.
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 Structure and Algorithms in C++*, 3rd edition, Pearson Education, 2006.

7 List of Major Courses within Elective

Sr. No.	Course Code	Course Title	Pre-Requisite	Credit hours
1.	MTH-210	Elementary Number Theory	Nil	3
2.	MTH-430	Tensor Analysis	Differential Geometry	3
3.	MTH-308	Analytical Mechanics	Nil	3
4.	MTH-310	Integral Equations	Nil	3
5.	MTH-403	Methods of Mathematical Physics	Nil	3
6.	MTH-431	Advanced Numerical Methods	Numerical Methods	3
7.	MTH-405	Measure Theory and Lebesgue Integration	Nil	3
8.	MTH-406	Modeling and Simulations	Nil	3
9.	MTH-407	Fluid Mechanics-I	Nil	3
10.	MTH-408	Analytical Dynamics	Nil	3
11.	MTH-409	Special Theory of Relativity	Nil	3
12.	MTH-411	Rings and Fields	Nil	3
13.	MTH-412	Theory of Modules	Nil	3
14.	MTH-432	Advanced Group Theory	Abstract Algebra	3
15.	MTH-415	Fuzzy Algebra	Nil	3
16.	MTH-416	Plasma Theory	Nil	3
17.	MTH-417	Introduction to Quantum Mechanics	Nil	3
18.	MTH-418	Fluid Mechanics-II	Fluid Mechanics-I	3
19.	MTH-419	Semigroups	Nil	3
20.	MTH-420	Operations Research	Nil	3
21.	MTH-421	Introduction to Bio Mathematics	Nil	3
22.	MTH-422	Functional Analysis	Nil	3
23.	MTH-423	Optimization Techniques	Nil	3

24.	MTH-424	Introduction to Finite Element Method	Nil	3
25.	MTH-425	Graph Theory	Nil	3
26.	MTH-426	Programming with MATLAB	Nil	3
27.	MTH-426L	Programming with MATLAB(Lab)	Nil	3
28.	MTH-427	Mathematical Programming in Python	Nil	3
29.	MTH-427L	Mathematical Programming in Python(Lab)	Nil	3
30.	MTH-428	Industrial Mathematics	Nil	3

8 Course Outlines for Major Courses within Elective

Elementary Number Theory

BS-Mathematics

Course Code: MTH-210

Credit Hours: 03

Pre-requisite: Nil

Objectives

To introduce students to language and methods of the area of elementary linear algebra. To help students in gaining the understanding of mathematical reasoning and to develop their problem solving skills.

Learning Outcomes

- To interpret the concepts of divisibility, prime number, least common multiple, greatest common divisor, division algorithm and Euclidean algorithm.
- To demonstrate uniqueness of distinguishing prime number factors at integers by means of the fundamental theorem of arithmetic.
- To present a rigorous development of Diophantine equation using axioms, definitions, examples, theorems and their proofs. The goal of linear congruence is to describe a method of solving such equations. As a practical application, the decryption key in the RSA algorithm is obtained by solving the linear congruence equation. The students will learn the applications of the Chinese remainder theorem that is widely used for computing with large integers.

Course Outline

Unit 1. Prime Numbers

The sieve of Eratosthenes, perfect numbers, Mersenne primes, Fermat numbers, Theorems related to prime numbers.

Unit 2. Divisibility

Divisibility of primes, divisibility tests.

Unit 3. Euclidean algorithm

The Euclidean algorithm, the equation $ax + by = c$.

Unit 4. Congruences

Linear congruences. Techniques for solving $ax \equiv b \pmod{m}$.

Unit 5. Applications of Congruences

The Chinese remainder theorem. Finding the day of the week.

Recommended Books/Reference Material

1. Burton, D.M.(2010), *Elementary Number Theory*. McGraw Hill.
2. Effinger, G. and Mullen, G.L. (2021), *Elementary Number Theory*. CRC Press,
3. Iwaniec, H., and Kowalski, E. (2021). *Analytic Number Theory*. American Mathematical Society.
4. Landau, E. (2021)., *Elementary Number Theory*. American Mathematical Society.
5. Nagell, T. (2021)., *Introduction to Number Theory*. American Mathematical Society.

Tensor Analysis

BS-Mathematics

Course Code: MTH-430

Credit Hours: 03

Pre-requisite: Differential Geometry

Objectives

Main objective of this course is to enhance the capability of students to learn geometry in the sense of advanced calculus, topological point of view. They will develop a foundation of manifolds, tensor analysis and Riemannian geometry.

Learning Outcomes

- Students must learn basics of manifolds.
- Understand tensor algebra and their transformation laws.

Course Outline

Unit 1. Theory of Manifolds

Historical background of manifolds, coordinate and proper coordinate patches on manifolds, definitions and examples of manifolds.

Unit 2. Tangents Spaces and Vector Fields

Definition of tangents and its example, vector fields, tangent spaces, dual spaces, multi linear functions, differential map and sub- manifolds.

Unit 3. Algebra of Tensors

Algebraic operations on tensor, Lie derivatives, Lie brackets, differential forms.

Unit 4. Tensors on Manifolds

Transformation laws of tensors on manifolds, contravariant, covariant and mixed laws of transformation of tensor, metric tensor, affine connections, Christoffel symbols, connection symbols.

Unit 5. Differentiation of Mixed Laws of Tensors and Geodesic

Contravariant, covariant and mixed differentiation, Riemannian and semi Riemannian metrics, curvature and torsion tensor, connection of a semi-Riemannian tensor, Einstein and Ricci tensor, killing equations and Killing vector fields, geodesics and their related problems.

Recommended Books/Reference Material

1. De, D. (Ed.). (2022). *Introduction to Differential Geometry with Tensor Applications*. John Wiley & Sons.
2. Millman, R. S., Parker, G. D. (1977). *Elements of differential geometry*. Prentice-Hall.
3. O'Neill, B. (2014). *Elementary differential geometry*. Elsevier Science.
4. Robbin, J. W., Salamon, D. A. (2022). *Introduction to Differential Geometry*. Springer Berlin Heidelberg.
5. Sahraee, S., & Wriggers, P. (2023). *Tensor Calculus and Differential Geometry for Engineers: With Solved Exercises*. Springer Nature.

Analytical Mechanics

BS-Mathematics

Course Code: MTH-308

Credit Hours: 03

Pre-requisite: Nil

Objectives

Introduction of rigid body in one, two and three-dimensional relation between the fixed and rotating frame of reference.

Learning Outcomes

- Method of finding moment of inertia of rigid bodies of different shapes and sizes.
- Principle axes and principle moment of inertia of different rigid bodies by different methods.
- Angular velocity and kinetic energy of laminas.
- Methods of finding Euler's dynamical equation from fixed frame of reference to the body frame of references.
- Euler's geometrical equation.

Course Outline

Unit 1. Kinematic of a Rigid Body

Frame of reference and inertial frame of reference, Motion of a rigid body, Euler's theorem, center of mass of a system of particles, equation of motion and a rotating frame of reference.

Unit 2. Moment of Inertia of Different Rigid Bodies

Proof of some relations between angular momentum, moment of inertia, angular velocity and kinetic energy. Moment of inertia of a rod, laminas, circular disc, solid cylinder, hollow cylinder and parallelepiped, parallel axes theorem, perpendicular axes theorem.

Unit 3. Equi-Momental System

Angular momentum and principle reference, related topics of principle moments, principle directions and equimomental system. Discussion of motion of a rigid body in a plane and in space. Introduction to Euler's dynamical equations for the rigid body rotating about a fixed point. Euler's geometrical equations the stability of rotation of a rigid body. Moment of inertia about the principle axes. Moment of inertia of a right circular cone about its axis of symmetry (an axis through its vertex and parallel to its base and along the diameter at the base). Moment of inertia of a sphere, hemi-sphere, truncated cone, solid sphere and hollow sphere. Moment of inertia of cylinders. Equi-momental system of particles for a uniform rod, uniform triangular lamina and uniform solid cuboids.

Unit 4. Euler's Dynamical Equation and Euler's Angles

Euler's dynamical equation. Torque-free motion of a rigid body. Stability of a rotating rigid body. Euler's angles and rigid body motion. Angular momentum and kinetic energy of laminas (square and rectangle about their diagonal). Principal moment of inertia of square plate, rectangular plate about their diagonals and principle axis of rigid bodies.

Unit 5. Equilibrium, Momental and Ellipsoids of Rigid Body

Momental ellipsoid of elliptic plate, cube and hemispherical shell. Equation of a momental ellipsoid at a point on the circular edge of a solid cone. Lami's theorem, Moment of a force about a point. Varignon's theorem. Equivalent couples. First, second and third conditions of equilibrium. Stable, unstable and neutral equilibrium.

Recommended Books/Reference Material

1. Alrasheed, S. (2019). *Principles of mechanics: Fundamental University physics*, Springer Nature.
2. Kleppner, D., & Kolenkow, R. (2014). *An introduction to mechanics*. Cambridge University Press.
3. Lemos, N. A. (2018). *Analytical mechanics*. Cambridge University Press.
4. Lurie, A. I. (2013). *Analytical mechanics*. Springer Science & Business Media.
5. Philpot, T.A., and Thomas, J.S. (2020). . *Mechanics of Materials: An Integrated Learning System*, John Wiley & Sons..
6. Spiegel, M.R. (2021). *Theoretical Mechanics*. McGraw Hill Book Company.

Integral Equations

BS-Mathematics

Course Code: MTH-310

Credit Hours: 03
Pre-requisite: Nil

Objectives

Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. This course will help students to gain insight into the application of advanced mathematics and guide them through derivation of appropriate integral equations governing the behavior of several standard physical problems.

Learning Outcomes

- To understand the application of VIEs and FIEs.
- To equip students with the ability to apply advanced levels of integral equations.
- To develop research capability of students in the field of applied science.
- Students will gain understanding about the Green's function and calculus of variations.
- Students will understand the concepts of perturbation theory.

Course Outline

Unit 1. Introduction to Integral Equations

Theory of integral equations. Types of integral equations. Solution of integral equations.

Unit 2. Volterra Integral Equations

Volterra integral equations. Relationship between differential and Volterra equations.

Unit 3. Fredholm Integral Equations

Fredholm theory of integral equations. Leibniz rule.

Unit 4. Analytical Methods for Solution of Different Integral Equations

Successive approximation method on FIEs, VIEs, FIDEs, VIDEs. Successive substitution method for FIES on first kind. Determination of resolvent kernel and solution of IEs by resolvent kernel method.

Unit 5. Wiener-Hopf Techniques

Series solution method FIEs and VIEs. Introduction to Wiener-Hopf techniques.

Recommended Books/Reference Material

1. Mikhlin, S. G. (2020). *Linear integral equations*. Courier Dover Publications.
2. Singh, H., Dutta, H., & Cavalcanti, M. M. (2021). *Topics in Integral and Integro-Differential Equations*. Springer International Publishing.
3. Sharma, D. C., & Goyal, M. C. (2017). *Integral equations*. PHI Learning Pvt. Ltd..

- 4 Wyld, H.W. and Powell, G. (2020). *Mathematical Methods for Physics*. CRC Press.
5. Wazwaz, A. M. (2015). *First Course In Integral Equations*, A. World Scientific Publishing Company.

Methods of Mathematical Physics

BS-Mathematics

Course Code: MTH-403

Credit Hours: 03

Pre-requisite: Nil

Objectives

Physics is the study of the physical properties of the universe and of the fundamental properties and interactions of matter and energy. Physics has applications in every field of pure and applied science, such as engineering, optics, material science, space science, and medicine. The aim of mathematical physics is to adapt concept and methods of pure mathematics to study physical problems. The plan is to focus on the most recent advances in analytical techniques of particular use to researchers in the field of mathematical physics that covers a very wide area of topics and has a key role in interdisciplinary studies including mathematics, mechanics, and physics.

Learning Outcomes

- Students will gain understanding about the Green's function and calculus of variations.
- Students will understand the concepts of perturbation theory.

Course Outline

Unit 1. Green's Functions

The Dirac delta function. Existence of Green's function. Solution of B.V problems using Green's functions. Modified Green's function, illustrated examples. Eigen function expansion method and its numerical application for ODE's.

Unit 2. Eigen Function Expansion Method

Eigen function expansion method and its numerical application for PDE's. Green's function associated with two dimensional problems. Solutions of non-homogeneous problems.

Unit 3. Calculus of Variation

Preliminaries. Examples of variational problems. Euler lagrange equation. Fundamental theorem of the calculus of variations, special cases. Procedure for obtaining the variation of the functional with examples.

Unit 4. Euler Lagrange Equation

Euler-Lagrange equation with one independent many dependent variables. Euler Lagrange equation with higher order derivatives. Illustrative examples. Euler-lagrange for two and three independent variables. Constrained extrema.

Unit 5. Perturbation Methods

Perturbation methods for algebraic equations. Perturbation methods for ordinary differential equations.

Recommended Books/Reference Material

1. Karapetyants, A. N. and Vladislav, V. K. (2022). *Methods of Mathematical Physics: Classical and Modern*. Springer.
2. Morgan, L. (2022). *A Modern Approach to Mathematical Physics*. Murphy and Moore.
3. Svozil, K. (2020). *Mathematical Methods of Theoretical Physics*. World Scientific Publishing Company.
4. William, H.W. and Powell, G. (2022). *Mathematical Methods for Physics*. CRC Press.
5. Wyld, H.W. and Powell, G. (2020). *Mathematical Methods for Physics*. CRC Press.

Advanced Numerical Methods

BS-Mathematics

Course Code: MTH-431

Credit Hours: 03

Pre-requisite: Numerical Methods

Numerical analysis is the study of algorithms for solving problems of continuous mathematics. This course provides an introduction to several fundamental algorithms for solving scientific problems along with their derivation and application. Students will learn to apply these algorithms.

Learning Outcomes

- Students will be able to solve difference equations, solve the ordinary differential equation.
- Students will learn the numerical differentiation and numerical quadrature.

Course Outline

Unit 1. Numerical Differentiation with Unequally Spaced Arguments

Definition and uses of numerical differentiation. Derivatives using Lagrange interpolation. Formula (Newton divided difference interpolation formula).

Unit 2. Numerical Differentiation with Equally Spaced Arguments

Derivatives using Newton Gregory Forward Difference Interpolation Formula, Newton Gregory Backward Difference Interpolation Formula, Stirling Formula, Bessel's Formula, Gauss Forward Difference Interpolation Formula, Gauss Backward Difference Interpolation Formula. Lab Work: In MATLAB / Mathematica / Python.

Unit 3. Numerical Integration

Definition and significance of numerical integration. Derivation, application and error analysis of rectangular rule. Trapezoidal rule. Simpson 1/3 rule. Simpson 3/8 rule. Boole's rule, Weddle's rule. Quadrature formulas (Gauss-Legendre 2-points quadrature formula, Gauss-Legendre 3-points quadrature formula).

Unit 4. Difference Equations

Introduction. Order and degree of a difference equation. Solution of a difference equation. Linear homogeneous difference equation with constant coefficients. Linear non-homogeneous difference equation with constant coefficients. Lab Work: In MATLAB / Mathematica / Python.

Unit 5. Ordinary Differential Equations

Numerical Methods for the solution of ODE's: Euler's Method. Heun's Method. Modified Euler's Cauchy Method. Taylor Series Method. Piccard's Method. Rung-Kutta Methods. Lab Work: In MATLAB / Mathematica / Python.

Recommended Books/Reference Material

1. Asadi, F. (2022). *Applied Numerical Analysis with MATLAB, /Simulink: For Engineers and Scientists*. Springer Nature.
2. Leader, J. J. (2022). *Numerical Analysis and Scientific Computation*. CRC Press.
3. Linz, P. (2019). *Theoretical Numerical Analysis*. Courier Dover Publications.
4. Rao, K. S. (2017). *Numerical methods for scientists and engineers*. PHI Learning Pvt. Ltd.
5. Van Kan, J. J. I. M., Segal, A., & Vermolen, F. J. (2023). *Numerical methods in scientific computing*.

Measure Theory and Lebesgue Integration

BS-Mathematics

Course Code: MTH-405

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to understand the concepts of Lebesgue measure and integration. To improve the skill of students in advanced analysis in pure mathematics.

Learning Outcomes

- Students must be able to understand the basic concept of measure theory and Lebesgue integration.

Course Outline

Unit 1. Measurable Sets

Fundamental concepts of set theory. Rings (sigma ring). Algebra (sigma algebra) of sets. Measurable Sets. Outer measure. Lebesgue measure.

Unit 2. Lebesgue Measure

Lebesgue measure (definition and examples). Lebesgue measurable sets. Borel sets, non-measurable sets.

Unit 3. Measurable Functions

Measurable functions (definition and examples). Borel measurable functions. Little wood three principles.

Unit 4. Simple Functions

Simple function. Characteristics functions. Review of Riemann integral. Absolute continuity and convex integration.

Unit 5. Lebesgue Integration

The Lebesgue integral, The integral of a non-negative function. Integral of measurable functions. Differentiation and integration.

Recommended Books/Reference Material

1. Cohn, D. L. (1980). *Measure Theory*, Birkhäuser.
2. Florescu, L.C. (2021). *Lebesgue Integral*. Springer International Publishing.
3. Guenther, R. B. and John, W. L. (2023). *Aspects of Integration: Novel Approaches to the Riemann and Lebesgue Integrals*. CRC Press.
4. Kadets, V. (2018). *A Course in Functional Analysis and Measure Theory*. Springer International Publishing.
5. Kubrusly, C.S. (2015). *Essentials of Measure Theory*. Springer International Publishing.
6. Royden, H. L., & Fitzpatrick, P. (1968). *Real analysis (Vol. 2)*. New York: Macmillan.
7. Schilling, R.L. and Kühn, F. (2021). *Counter examples in Measure and Integration*. Cambridge University Press.

Modeling and Simulations

BS-Mathematics

Course Code: MTH-406

Credit Hours: 02

Pre-requisite: Nil

Objectives

This is an introductory course of modeling concerned with the techniques for setting up the equations in specific applications in all the major areas such as engineering, ecological systems, biological systems, financial systems, economics. Students will also be able to develop an understanding simulation.

Learning Outcomes

After completion of this course, students will be able to

- Investigate quickly the effects of change in real life situations that take place over several years.
- To understand complex systems that would otherwise be difficult to investigate.

Course Outline

Unit 1. Differential Equations Models

Concepts of modeling and simulation. Linear and non-linear differential equations. Integral equations.

Unit 2. Modeling with First Order Differential Equations

Modeling with first order differential equations. Population dynamics. radioactive decay model. Model for Newton's law of heating and cooling. Motion in a gravitational field. Mixing problem model. Series circuit model.

Unit 3. Non-Linear Models and Modeling with Systems of First Order DEs

Non-linear model involving logistic equation and its modification; Non-linear model for chemical reactions. Competitive hunter model. Predator-prey model.

Unit 4. Modeling with Second Order Differential Equations

Modeling with second order differential equations. Application to biological systems. Modeling with periodic or impulse forcing functions.

Unit 5. Modeling and Simulation

Introduction to simulation, objective, background. Difference between modeling and simulation. Techniques of simulation (simulate at least one system). Modeling heat equation and some application.

Recommended Books/Reference Material

1. Borzì, A. (2020). *Modelling with ordinary differential equations: a comprehensive approach*. CRC Press.

2. Göttlich, S., Herty, M., & Milde, A. (Eds.). (2021). *Mathematical Modeling, Simulation and Optimization for Power Engineering and Management*. Springer Nature.
3. Jerri, A. J. (2008). *Introduction to integral equations with applications*. John Wiley & Sons.
4. Ledder, G. (2005). *Differential equations: a modeling approach*. McGraw-Hill Higher Education.
5. Singh, V. K., Sergeyev, Y. D., & Fischer, A. (2021). *Recent Trends in Mathematical Modeling and High Performance Computing*. Springer International Publishing.
6. Zill, D. G. (2012). *A first course in differential equations with modeling applications*. Cengage Learning.

Modeling and Simulations (Lab)

BS-Mathematics

Course Code: MTH-406L

Credit Hours: 01

Pre-requisite: Nil

Objectives

This is an introductory lab course of modeling concerned with the techniques for setting up the equations in specific applications. The application of mathematical modelling is linked with all the major areas in mathematics such as engineering, ecological systems, biological systems, financial systems, economics, etc., one approximates the actual situation by an idealized model.

Learning Outcomes

After completion of this course, students will be able to

- Apply quickly the effects of change in real life situations that take place over several years.
- Understand complex systems that would otherwise be difficult to investigate.

Unit 1. Introduction to Mathematical Modeling

Introduction to Mathematical Modelling, Different types of mathematical models- deterministic, stochastic, static, dynamic and transient models etc. Some examples of mathematical models from environmental, biological sciences and technological domains.

Unit 2. System Characterization

System Characterization-Introduction, basic concepts of system, variable and parameters, degree of detail, time- dependence, specificities of deterministic and stochastic models.

Unit 3. Modeling Processing

Modeling process, identification of involved processes and sub-processes, mathematical formulations of individual (sub)processes, consolidation of equations and validation of equation set.

Unit 4. Algorithm Development

Solution Algorithm development-Linear, nonlinear Algebraic equations, Algebraic-Differential equations, Ordinary differential equations, Partial differential equations, mixed equation; appropriate solution methods for each class.

Unit 5. Computer Implementation

Computer implementation of the model-Using Symbolic computation package; computer program design and adaptation, computation environment, environmental and package constraints Computer implementation of the model-Using Higher Level programming Language. Computer program design and adaptation, computation environment, environmental and language constraints. Top-down and bottom-up program design strategies, identification of processes and sub-processes and their transformation into program components. Analysis-Design-Construction-Testing model development life cycle.

Unit 6. Model Analysis and Simulation

Model Validation; general consideration of model validity, Are the produced results physical? Model calibration-adjustment of adjustable parameters. Unreliable computations, Analysis of mathematical errors in modeling computation. Sensitivity analysis. Model implementation and its use, Use of computer model for analysis, control and design of the system, Proto-typing and scaling of the system, Evaluation of what-if scenarios with varied data, Numerical Simulation-Introduction, structure of Continuous and Discrete Simulation models, Special purpose simulation languages. Applications Application of simulation models. Case Studies for different domains.

Recommended Books/Reference Material

1. Kapur, J. N. *Mathematical Modelling*. New age Int. Publishers.
2. Frank R. Giordano, William P. Fox and Steven B. Horton. (2013). *A First Course in Mathematical Modeling*.
3. Mark M. Meerschaert. (2013). *Mathematical Modeling*. 4th ed.

Fluid Mechanics-I

BS-Mathematics

Course Code: MTH-407

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is aimed to give in depth understanding to types of fluids, nature of flows and concepts related to fluid dynamics. It also focuses on providing strong foundation and application of fluid mechanics.

Learning Outcomes

- Develop understanding for fluid mechanics and various types of motions.
- Enable the students to learn of ideal fluid conditions and apply the rules of vortex line and Helmholtz vorticity theorem.

Course Outline

Unit 1. Introduction to Fluid Mechanics

Introduction to fluid mechanics, fluid fields and continuum concepts. Types of fluids, types of flows. Local and particle rate of change, compressibility. Stream functions. Basic hydrostatic equation.

Unit 2. Continuity Equation

Equation of continuity. Surface and body forces, viscosity. Velocity potential, streamlines and path lines.

Unit 3. Euler's and Bernoulli's Equation

Euler's equations of motions, Bernoulli's equation. Helmholtz vorticity equation and Helmholtz vorticity theorem. Uniqueness theorem.

Unit 4. Vortex Motion

Vortex line, vortex sheet. Kelvin's minimum energy theorem. Fluid streaming past a circular, cylinder, irrotational motion produced by a vortex filament.

Unit 5. Source, Sink and Doublets

Stoke's stream function. Impulsive motion sources. Sinks. Doublets. Images in rigid infinite plane and solid sphere.

Recommended Books/Reference Material

1. Bhimsen, K.S. (2022). *Introduction to Theoretical and Mathematical Fluid Mechanics*. Wiley.
2. Joseph, D. (2022). *Introduction to Fluid Mechanics*. McGraw Hill.
3. Liu, P. (2021). *A General Theory of Fluid Mechanics*. Springer.
4. Matsson, J. E. (2023). *An Introduction to Ansys Fluent*. SDC Publications.
5. Pozrikidis, C. (2017). *Fluid Mechanics, Theory, Application, and Numerical Simulation*. Springer.

Analytical Dynamics

BS-Mathematics

Course Code: MTH-408

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is designed to impart knowledge about methods of classical mechanics developed towards complicated oscillating systems. Primarily the aim is to create and demonstrate natural connection with Lagrangian and Hamiltonian approaches and its integrated use in solving the specific problems.

Learning Outcomes

- Provision of basic knowledge about generalized coordinates for a system of body with the application of Lagrangian and Routhian methods.
- Develop capacity to deal with the Hamilton theory and its application.
- Provide a comprehensive concept of dynamics of oscillating systems.

Course Outline

Unit 1. Introduction

Theory of mechanics with definitions and applications. Unconstrained motion and constrained motion, degree of freedom, generalized coordinates, holonomic and non-holonomic systems. D'Alembert's principle, d-delta rule.

Unit 2. Lagrange's Theory

Lagrange equations, generalization of Lagrange equations and numerical applications. Quasi coordinates, Lagrange equations in quasi coordinates. Energy integral, first integral of Lagrange equations of motion.

Unit 3. Hamilton's Theory

Hamilton's principle. Ignorable coordinates, Routhian function. Derivation of Hamilton's equation from a variational principle.

Unit 4. Lagrange's Theory of Non-Holonomic System and Canonical Transformation

Lagrange equations for Non-Holonomic Systems with and without Lagrange multipliers. Chaplygin's equations. Canonical transformations. Lagrange and Poisson brackets.

Unit 5. Hamilton Jacobi Theory

Infinitesimal exact transformation. Hamilton Jacobi Theorem.

Recommended Books/Reference Material:

1. Ardema, M. D. (2005). *Analytical dynamics: theory and applications*. Springer Science and Business Media.
2. Greenwood. T. D. (1977). *Classical Dynamics*. Inc Prentice-Hall.
3. Goldstein, H. (2011). *Classical Mechanics*. Pearson.
4. Menard, K. P., & Menard, N. (2020). *Dynamic mechanical analysis*. CRC press.
5. Shabana, A. A. (2020). *Dynamics of multibody systems*. Cambridge university press.

Special Theory of Relativity

BS-Mathematics

Course Code: MTH-409

Credit Hours: 03

Pre-requisite: Nil

Objectives

The aim of this course is to enable the student to learn about basic definitions and concepts of Tensor and Special Relativity. In addition, students will be able to know about Lorentz transformation and its application and learn about Minkowski space time and null cone. The further objective is to give students a clear concept of relativistic kinematics, Doppler shift and binding energy and understand about electromagnetism in relativity and well knowing about Maxwell's equations.

Learning Outcomes

- Introduction of special relativity and derivation of special relativity.
- Further application of special relativity in various mathematical domains.

Course Outline

Unit 1. Introduction

Introduction, basic definitions, tensor. Einstein's formulation of special relativity. Lorentz transformation and its application.

Unit 2. Derivation of Special Relativity

Length contraction, time dilation and simultaneity. Velocity addition formulae. 3-dimensional Lorentz transformation.

Unit 3. The Four-Vector Formulation of Special Relativity

4-vector, 4-momentum, 4-forces, Lorentz transformation in 4-vector formalism. The Lorentz and Poincare groups, proper time. Minkowski space time. Null cone structure.

Unit 4. Applications of Special Relativity

Relativistic Kinematic. Doppler shift in relativity, Compton effect. Particle scattering, binding energy. Particle production and decay.

Unit 5. Electromagnetism in Special Relativity

Electric current, Maxwell's equations and electromagnetic waves. The four-vector formulation of Maxwell's equation. Special relativity with small acceleration.

Recommended Books/Reference Material:

1. Dray, T. (2021). *The geometry of special relativity*. CRC Press
2. Qadir, A. (1989). *Relativity: An introduction to the special theory*. World Scientific.
3. Rafelski, J. (2022). *Modern special relativity: a student's guide with discussions and examples*. Springer Nature.
4. Rindler, W. (1991), *Introduction to special relativity*, Clarendon Press
5. Thorne, K. S., & Blandford, R. D. (2021). *Relativity and Cosmology: Modern Classical Physics*. Princeton University Press.

Rings and Fields

BS-Mathematics

Course Code: MTH-411

Credit Hours: 03

Pre-requisite: Nil

Objectives

In abstract algebra Ring theory is the study of rings and algebraic structures in which addition and multiplication are defined and have similar properties to those operations defined for the integers. Ring theory studies the structure of rings and their representations.

Learning Outcomes

- Rings, properties of rings and Gaussian integers.
- Students will also understand homomorphism, natural homomorphism of a ring, field extension.

Course Outline

Unit 1. Rings and Integral Domain

Properties of rings, rings of Gaussian integers. Characteristics of a ring. Zero divisor, finite integral domain. Fields, fields of quotients.

Unit 2. Sub Rings and Ideals

Sub Rings. Sub rings test. Ideals, ideal tests. Principal ideal. Prime ideal. maximal ideal.

Unit 3. Factor Rings and Ring Homomorphism

Existence of factor ring. Isomorphism. Properties of ring homomorphism. Kernel of homomorphism. natural homomorphism from ring to its factor ring.

Unit 4. Polynomial Rings

Polynomial rings. Polynomial rings over a field. Unique factorization domain. Principal ideal domain. Euclidean domain.

Unit 5. Extension Fields

The fundamental theorem of field theory. Splitting fields. Algebraic extensions. Degree of an extension. Finite extension.

Recommended Books/Reference Material

1. Fraleigh, J. B. (2003). *A first course in abstract algebra*. Pearson Education India.
2. Gubareni, N. (2022). *Introduction to Modern Algebra and Its Applications*. CRC Press.
3. Herstein, I. N. (1991). *Topics in algebra*. John Wiley & Sons.
4. Lawrence, J. W., Zorzitto, F. A. (2021). *Abstract Algebra: A Comprehensive Introduction*. Cambridge University Press.
5. Weintraub, S. H. (2022). *Introduction To Abstract Algebra, An: Sets, Groups, Rings, And Fields* World Scientific Publishing Company.

Theory of Modules

BS-Mathematics

Course Code: MTH-412

Credit Hours: 03

Pre-requisites: Nil

Objectives

This is a course in abstract linear algebra. The majority of follow up courses in both pure and applied assume the material covered in this course.

Learning Outcomes

- students will understand finitely generated modules and direct sum of modules, cyclic modules, free modules, quotient modules, homeomorphisms of modules and isomorphism modules.
- Students will know about short exact sequences of modules, group of module homeomorphisms and modules over PID's, simple modules, artinian modules.
- Students will learn about Noetherian modules, modules of finite length, Artinian rings, Noetherian rings and radicals, nil radical, Jacobson radical.

Course Outline

Unit 1. Basis Theory of Modules

Modules and generation of modules. Submodules and examples. Finitely generated modules, direct sum of modules.

Unit 2. Quotient Modules and Homomorphisms

Cyclic modules, quotient modules. Homomorphisms, theorems and examples.

Unit 3. Free Modules and Short Exact Sequence and Projective, Injective Modules

Free modules, torsion modules. Short exact sequence modules. Group of module homomorphisms. Projective modules, injective modules. modules over PID's.

Unit 4. Simple, Artinian and Noetherian Modules

Simple modules. Artinian modules. Noetherian modules. Modules of finite length. Artinian rings, Noetherian rings.

Unit 5. Radicals

Radicals, nil radical. Jacobson radical.

Recommended Books/Reference Material

1. Golan, J. S., & Head, T. (2017). *Modules and the structure of rings: a primer*. CRC Press.
2. Jensen, C. U. (2022). *Model theoretic algebra with particular emphasis on fields, rings, modules*. Routledge.
3. Musili, C. (1994). *Introduction to rings and modules*. Narosa Publishing House.
4. Oberst, U., Scheicher, M., & Scheicher, I. (2020). *Linear Time-Invariant Systems, Behaviors and Modules*. Springer International Publishing.
5. Papikian, M. (2023). *Drinfeld modules*. Springer Nature.

Advanced Group Theory

BS-Mathematics

Course Code: MTH-432

Credit Hours: 03

Pre-requisite: Abstract Algebra

Objectives

In this course we will study more advanced structure of group theory which is very helpful for students those want to do research in the field of group theory.

Learning Outcomes

- Preparation for further study or research in Mathematics or related fields where group theory plays an important role, fostering an interest in exploring advanced topics independently.
- Proficiency in solving complex problems related to group theory.

Course Outline

Unit 1. Sylow Theorems

P-Groups, Sylow p -subgroups, definitions, examples and related results. Cauchy theorem for abelian groups, Sylow's first theorem, Sylow's 2nd and 3rd theorem. Simple groups, applications of Sylow's theorems.

Unit 2. Series in Group

Series of groups, normal series, Zassenhaus lemma. Refinement of a normal series, subnormal series, Schreier's refinement theorem. Jordan-Holder theorem, composition series, chief series.

Unit 3. Solvable Groups and Nilpotent Groups

Solvable groups. Theorems on solvable groups. Nilpotent groups. Lower and upper central series. Characterization of finite nilpotent groups.

Unit 4. Free Groups

The free groups, basic theorems. Free products of groups.

Unit 5. Linear Groups

Linear groups and types of linear groups. Representations of linear groups. Group algebra and representation modules.

Recommended Books/Reference Material

1. Al Subaiei, B., and Al Nuwairan M. (2023). A Gentle Introduction to Group Theory. Springer.
2. Davvaz,, B. (2021). *Groups and Symmetry: Theory and Applications*. Springer.

3. Fraleigh, J.B. (2002). *A First Course in Abstract Algebra*. Addison-Wesley Publishing Company.
4. Humphreys, J. F. (1996). *A Course in Group Theory*. Oxford University Press, USA.
5. Judson, T. W. (2020). *Abstract algebra: theory and applications*.

Fuzzy Algebra

BS-Mathematics

Course Code: MTH-415

Credit Hours: 03

Pre-requisite: Nil

Objectives

The main objective of this course is to understand the basic concept of Fuzziness and different structures like fuzzy rings, fuzzy semigroups.

Learning Outcomes

- Students must be able to understand logical ways in pure mathematics.
- Students will be able to analyze fuzzy relations and graphs.

Course Outline

Unit 1. Fuzziness

Introduction, the concept of fuzziness and examples. Mathematical modelling, Operations of fuzzy sets.

Unit 2. Algebra of Fuzzy Sets

Boolean algebra and lattices, equivalence relations and partition. composing mappings, alpha-cuts. Image of alpha-level sets, operations on fuzzy sets.

Unit 3. Fuzzy Relations

Definition and examples. Binary fuzzy relations. Operations on fuzzy relations, fuzzy partitions.

Unit 4. Fuzzy SemiGroups

Fuzzy ideals of semigroups. Fuzzy quasi-ideals, fuzzy bi-ideals of semigroups. Characterization of different classes of semigroups by the properties of their fuzzy ideals. Fuzzy quasi-ideals and fuzzy bi-ideals.

Unit 5. Fuzzy Rings

Fuzzy ideals of rings. Prime, semi prime fuzzy ideals. Characterization of rings using the properties of fuzzy ideals.

Recommended Books/Reference Material

1. De Silva, C.W. (2018). *Intelligent Control: Fuzzy Logic Applications*. CRC Press.
2. Nguyen, H.T., Walker, C., and Walker, E.A. (2018). *A First Course in Fuzzy Logic*. Chapman and Hall/CRC.
3. Singh, A. K., Chiclana, F., and Carter, J. (2021). *Fuzzy Logic Recent Applications and Developments*. Springer International Publishing.
4. Voskoglou, M. (2020). *Fuzzy Sets, Fuzzy Logic and Their Applications*. MDPI AG.
5. Zadeh, L.A. and Aliev, R.A. (2018). *Fuzzy Logic Theory and Applications: Part I and Part II*. World Scientific Publishing.

Plasma Theory

BS-Mathematics

Course Code: MTH-416

Credit Hours : 03

Pre-requisite: Nil

Objectives

This course is specifically designed to provide an in depth overview of behavior of plasma particles and magnetic fields, individually as well as in fluids. In addition, the course also aims to give understanding about how oscillations and waves are generated in plasma.

Learning Outcomes

- Students will have outstanding concepts about the nature of plasma, its occurrence and various forms in fluids.
- Ability to comprehend and demonstrate the occurrence waves especially electromagnetic and electrostatic ion waves.

Course Outline

Unit 1. Introduction

Occurrence of plasma in nature. Definition of plasma. Plasma parameters. Criteria for plasma.

Unit 2. Single Particle Motion

Application of plasma. Motion of single particle motion with uniform **E** and **B** field with non-uniform **B** field and **E** field. Time varying **E** field and **B** field.

Unit 3. Plasmas as Fluids

The fluid equation of motion. Fluid drifts perpendicular and parallel to **B**. Representation of waves. Group velocity.

Unit 4. Waves in Plasmas

Plasma oscillations. Ion waves. Validity of plasma approximation. Electrostatic ion waves perpendicular to B_0 .

Unit 5. Diffusion and Resistivity

The lower Hybrid frequency. Electromagnetic waves with $B_0 = 0$, perpendicular to B_0 and parallel to B_0 . Cutoffs and resonance. Magnetosonic waves. Hydro-magnetic equilibrium.

Recommended Books/Reference Material

1. Bellan, P. M. (2008). *Fundamentals of plasma physics*. Cambridge university press.
2. Chen, F. F. (2012). *Introduction to plasma physics*. Springer Science & Business Media.
3. Fitzpatrick, R. (2022). *Plasma Physics: An Introduction*: CRC Press.
4. Goldston, R.J. (2020). *Introduction to Plasma Physics*. CRC Press.
5. Pert, G.J. (2021). *Foundations of Plasma Physics for Physicists and Mathematicians*, John Wiley & Sons.

Introduction to Quantum Mechanics

Course Code: MTH-417

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is aimed to provide introductory information about quantum mechanics. The focus of this course is on providing a strong foundation and application of quantum mechanics.

Learning Outcomes

- This course will develop understanding for quantum mechanics and its application in orbital and angular motions.
- It will enable the students to apply the eigen values and eigen states in the Schrodinger equation of motion.

Course Outline**Unit 1. Basics Definition and Properties of Quantum Mechanics**

Basic postulates of Quantum Mechanics. State vector. Formal properties of quantum mechanical operators.

Unit 2. Application of Eigen values

Eigen values and eigen states. Simple harmonic oscillator. Schrodinger equation of motion and its properties.

Unit 3. Concept of Potential Terminologies

Potential step. Potential barrier. Potential well.

Unit 4. Angular Momentum

Orbital angular momentum. Motion in a centrally symmetric field. Hydrogen atom. matrix representation of angular momentum and spin.

Unit 5. Perturbation

Time independent perturbation theory. Degeneracy. The Stark effect. Introduction to relativistic Quantum Mechanics.

Recommended Books/Reference Material

- 1 Ballentine, L. E. (2014). *Quantum mechanics: a modern development*. World Scientific Publishing Company.
- 2 Cattani, G. H., & Quemy, A. (2023). *Case-Based and Quantum Classification for ERP-Based Brain-Computer Interfaces*. Brain Sciences.
- 3 Melnikov, A., Kordzanganeh, M., Alodjants, A., & Lee, R. K. (2023). *Quantum machine learning: From physics to software engineering*. Advances in Physics: X.
- 4 Liboff, R.L. (1991), *Introductory Quantum Mechanics*, Addison-Wesley 2nd Edition.

Fluid Mechanics-II

BS-Mathematics

Course Code: MTH-418

Credit Hours: 3

Pre-requisite: Fluid Mechanics – I

Objectives

This primary objective of this course is to enable students to have a strong grip on theoretical and applied concepts of fluid mechanics. In addition, it aims to develop better learning about vortex motion and irrotational motions.

Learning Outcomes

- Ability to comprehend problems related to fluid mechanics and their solutions.

Course Outline

Unit 1. Basics Concepts of Fluid Mechanics

Complex velocity potential. Constitutive equation. Navier Stoke's equation. Exact solution of Navier Stoke's equation. Conformal transformations.

Unit 2. Main Results of Fluid Mechanics

The cycle theorem, Blasius theorem. Joukowski's transformation, flow past an elliptic cylinder. Flow due to an oscillatory boundary.

Unit 3. Vortex and its Applications

Circular vortex. Motion of any vortex, vortex pair. Karman's vortex street

Unit 4 Flows of Fluid Mechanics

Connectivity. Poiseuille flow, Couette flow. Ekman flow. Steady and unsteady unidirectional flow, Flow over a flat plate, Sudden motion of a plane boundary in a fluid at rest.

Unit 5. Properties of Reynold's Number

Dynamical similarity and the Reynold's number. Flow over a flat plate. Reynold's equations of turbulent motion.

Recommended Books/Reference Material

1. Bhimsen, K.S. (2022). *Introduction to Theoretical and Mathematical Fluid Mechanics*. Wiley.
2. Chorlton. F, (2004)., *Textbook of Fluid Dynamics* , CBS Publishers & Distributors.
3. Fox, R. W., McDonald, A. T., & Pritchard, P. J. (2003) ,*Introduction to Fluid Mechanics*, John Wiley and Sons 2003.
4. Joseph, D. (2022). *Introduction to Fluid Mechanics*. McGraw Hill.
5. Matsson, J. E. (2023). *An Introduction to Ansys Fluent*. SDC Publications.
6. Schlichting, H. , Gersten, K., Krause, E. and Oertel, H. Jr., *Boundary-Layer Theory*, 8th Edition, Springer, 2004.
7. Thomson. M., (2011), *Theoretical Hydrodynamics*, 5th Edition, Dover Publications.

Semigroups

BS-Mathematics

Course Code: MTH-419

Credit Hours: 3

Prerequisite: Nil

Objectives

The aim of the course is to develop the study of the theory of semigroups in its ideals, homomorphism, Inverse and embedding of semi groups.

Learning Outcomes

- To understand the theory of semigroups and its embedding completely.

Course Outline

Unit 1. Semigroups , Ideals and Homomorphism

Groupoids, semigroup, transformation semigroup on a set X, translations and the regular representation of a semigroup. Subgroup of a semigroup, Group with a zero element. Ideals of a semigroups. The semigroup of relations on a set X, Congruence's, factor groupoids and homeomorphisms.

Unit 2. Cyclic Semigroups

Cyclic semi groups Unit No's and Maximal subgroups. Regular elements and inverses. Inverse semigroups.

Unit 3. Embedding of Semigroups

Embedding of semigroups in groups. Right groups semi groups. Examples.

Unit 4. Free Semigroups

Free semigroups and generating relations. The bicyclic semi groups. Green's relation. regular D Class.

Unit 5. O-Simple Semigroups

O-minimal ideals and O-simple semigroups. Principal factors of a semigroup. completely O-semigroups.

Recommended Books/Reference Material

1. Al-Tahan, M., Smarandache, F., & Davvaz, B. (2021). *Neutro Ordered Algebra: Applications to semigroups*, Springer.
2. Clifford, A. H. & Preston, G. B. 2000. *The Algebraic Theory of Semigroups*. American Mathematical Society.
3. Lipacheva, E. V. (2022). *Extensions of semigroups by the dihedral groups and semigroup C^* -algebras*. Journal of Algebra and Its Applications.
4. Mang, A., and Weber, M. (2021). *Categories of two-colored pair partitions Part II: Categories indexed by semigroups*. Journal of Combinatorial Theory, Series A.
5. Petrich, M. *Inverse semigroups in semigroup Forum*, Springer-Verlag.

Operations Research

BS- Mathematics

Course Code: MTH-420

Credit Hours: 03
Pre-requisite: Nil

Objectives

The objective is to provide a fundamental account of the basic results and techniques of linear programming (LP) and its related topics in operation research. There is an equal emphasis on all aspects of understanding, algorithms and applications. The course serves, together with topics on network models, as essential concepts and background for more advanced studies in operation research. The main focus of the course is on Linear Programming Models, Duality Problems and Sensitivity analysis, Transportation Models and Network Flow Models.

Learning Outcomes

Upon successful completion of this course,

- The students will be able to understand the basic techniques in operation research and formulation of problems, the fundamental concept and approach of linear programming appropriate to the further study of operation research.
- Students will also be able to demonstrate knowledge and understanding of the underlying techniques of the Simplex method and its extension such as the revised Simplex and dual Simplex algorithms. Students will understand and apply the theory of LP duality such as in the theory and computations of network optimization.

Course Outline

Unit 1. Introduction

Operation research model. Solving the OR models. Graphical LP solutions and selected LP applications. LP models in equation form. Transition from graphical to algebraic solution.

Unit 2. The Simplex Method

Artificial starting solution. Special cases in simplex method. Sensitivity analysis.

Unit 3. Definition of Dual Problem

Primal dual relationship. Dual simplex algorithm. Post optimal analysis.

Unit 4. The Transportation and Assignment Problem

Definition of transportation problem. Non-traditional transportation model. The transportation algorithm. The assignment model.

Unit 5. Network Optimization Models

Minimal spanning tree algorithm. Shortest route problem. Maximal flow model.

Recommended Books/Reference Material

1. Calma, A., Ho, W., Shao, L., & Li, H. (2021). *Operations research: topics, impact, and trends from Operations Research*, Springer.
2. Eiselt, H. A., & Sandblom, C. L. (2022). *Operations research: A model-based approach*. Springer Nature.
3. Hamdy A Taha, (2010), *Operation Research, An Introduction*, Prentice Hall.
4. Paul A. Jensen, Jonathan F. Bard, (2003), *Operation Research Models and Methods*, John Wiley and Sons Publishing Company.

Introduction to Bio Mathematics

BS-Mathematics

Course Code: MTH-421

Credit Hours: 03

Prerequisite: Nil

Objectives

The aim of the course is to describe the application of mathematical models to biological phenomena. A variety of contexts in human biology and diseases are considered, as well as problems typical of particular organisms and environments.

Learning Outcomes

- The students should have an enhanced knowledge and understanding of mathematical modeling and methods in the analysis of biological systems.

Course Outline

Unit 1. Continuous and Discrete Models

Continuous and discrete population models for single species. Models for interacting populations. Age-structured populations.

Unit 2. Epidemic Diseases

Stochastic population growth. Dynamics of infectious diseases. Historical aside on epidemics. Simple epidemic models and practical applications.

Unit 3. Investigation of Epidemic Disease Models

Modelling venereal diseases. Multi-Group model for gonorrhea and its control. Modelling of AIDS and HIV. Modelling the transmission.

Unit 4. HIV Disease Models

Dynamics of the human immunodeficiency virus (HIV). Modelling combination. Drug therapy. Delay model for HIV infection with drug therapy.

Unit 5. Existence and Stability of Population Dynamics Models

Modelling the population dynamics of acquired immunity to parasite infection. Age-dependent epidemic model and threshold criterion. Existence and stability of equilibrium. The disease-free equilibrium and its stability. The endemic equilibrium and its stability. Local and global stability.

Recommended Books/ Reference Material

1. Costa, D. G., & Schulte, P. J. (2023). *An Invitation to Mathematical Biology*. Springer Nature.
2. Farkas, M. (2001). *Dynamical models in biology*. Academic press.
3. Murray, J. D. (2002). *Mathematical biology I: an introduction*, Springer.
4. Velten, K. (2009). *Mathematical modeling and simulation: introduction for scientists and engineers*. John Wiley & Sons.

Functional Analysis

BS -Mathematics

Course Code: MTH-422

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course extends methods of linear algebra and analysis to spaces of functions, in which the interaction between algebra and analysis allows powerful methods to be developed. The course will be mathematically sophisticated and will use ideas both from linear algebra and analysis.

Learning Outcomes

- The course will be mathematically sophisticated and will use ideas both from Linear Algebra and Analysis.

Course Outline

Unit 1. Metric Spaces

Metric Spaces. Metric spaces, examples of metric spaces. Open sets, closed sets, convergence. Cauchy sequence in metric space. Neighborhood. Completeness of metric spaces.

Unit 2. Normed Spaces

Normed spaces and Banach spaces. Vector Space, normed space, Banach space, properties of normed spaces, finite dimensional normed spaces and subspaces, compactness and finite dimension.

Unit 3. Linear Operators

Linear Operators, bounded and continuous linear operators, linear functionals, linear operators and functionals on finite dimensional spaces. Normed spaces of operators, dual spaces.

Unit 4. Inner Product Space

Inner product spaces and Hilbert spaces. Properties of inner product spaces.

Unit 5. Orthonormal sets and sequences

Orthogonal complements and direct sums, Orthonormal sets and sequences.

Recommended Books/Reference Material

1. Brezis, H. (2011). *Functional analysis, Sobolev spaces and partial differential equations*. New York: Springer.
2. Conway, J. B. (2019). *A course in functional analysis*, Springer.
3. Guenther, R. B. and John, W. L. (2023). *Aspects of Integration: Novel Approaches to the Riemann and Lebesgue Integrals*. CRC Press.
4. Florescu, L.C. (2021). *Lebesgue Integral*. Springer International Publishing.
5. Schilling, R.L. and Kühn, F. (2021). *Counterexamples in Measure and Integration*. Cambridge University Press.

Optimization Techniques

BS -Mathematics

Course Code: MTH-423

Credit Hours: 03

Prerequisite: Nil

Objectives

Optimization theory is a fundamental topic in mathematics and engineering that deals with finding the best possible solution from a set of available options. Introduce students to the fundamental concepts of optimization, including objectives, decision.

Course Outline

Unit 1. The Mathematical Programming Problem

Formal statement of the problem, Types of maxima, the Weierstrass Theorem and the Local-Global theorem, Geometry of the problem

Unit 2. Classical Programming

The unconstrained case. The method of Lagrange multipliers. The interpretation of the Lagrange multipliers

Unit 3. Non-linear Programming

The case of no inequality constraints. The Kuhn-Tucker conditions. The Kuhn-Tucker theorem. The interpretation of the Lagrange multiplier. Solution algorithms

Unit 4. Linear Programming

The Dual problems of linear programming. The Lagrangian approach, existence, duality and complementary slackness theorems. The interpretation of the dual. The simplex algorithm. The Control Problem. Formal statement of the problem. Some special cases. Types of control. The Control problem as one of programming in on infinite dimensional space. The generalized Weierstrass theorem

Unit 5. Calculus of Variations

Euler equations. Necessary conditions. Transversality condition constraints

Unit 6. Dynamic Programming

The principle of optimality and Bellman's equation. Dynamic programming and the calculus of variations. Dynamic programming solution of multistage optimization problems

Unit 7. Maximum Principle

Co-state variables. The Hamiltonian and the maximum principle. The interpretation of the co-state variables. The maximum principle and the calculus of variations. The maximum principle and dynamic programming examples.

Recommended Books/Reference Material

- 1 Cartis, C., Gould, N.I., and Toint, P.L.(2022), *Evaluation Complexity of Algorithms for Nonconvex Optimization: Theory, Computation and Perspectives* (Society for Industrial and Applied Mathematics, John Wiley and Sons.
- 2 Chong, E. K., Lu, W. S., and Žak, S. H. (2023). *An Introduction to Optimization: With Applications to Machine Learning*. John Wiley & Sons.
3. Diwekar, U.M. (2020), *Introduction to Applied Optimization*, Springer Nature.
4. Jahn, J. (2020), *Introduction to the Theory of Nonlinear Optimization*, Springer Nature.

5. Rao, S.S. (2019), *Engineering Optimization: Theory and Practice*, John Wiley and Sons.

Introduction to Finite Element Method

BS-Mathematics

Course Code: MTH-424

Credit Hours: 03

Pre-requisite: Nil

Objectives

The finite element method is an effective approach for solving complicated engineering problems those cannot be handled by classical analytical methods. In this course the fundamentals of this method will be emphasized. The key objective of this course is to introduce the mathematical concepts of the finite element method for obtaining approximate solutions of the ordinary and partial differential equations. The learning process will be enhanced through rigorous assignments on mathematical softwares such as Matlab, Mathematica and Maple.

Learning Outcomes

- The students will be able to: Understand the basics of finite element approach. Apply the finite element method for one-dimensional problems.
- Implement the method on computational software's such as Mathematica, Maple, MATLAB.

Course Outline

Unit 1. Introduction

Introduction to finite element method and its applications;

Unit 2. Direct Methods

Direct approaches for discrete systems, Strong and weak forms for one dimensional problem.

Unit 3. Approximations

Approximation of trial solutions, Weight functions and Gauss quadrature for one dimensional problem.

Unit 4. Formulations

Finite element formulation for one dimensional problems.

Unit 5. Applications

Application on MATLAB.

Recommended Books/Reference Material

1. Hutton, D. V. (2004). *Fundamentals of finite element analysis*. Ist Edition, Publisher: The McGraw Hill Companies.
2. Belytschko, J. F. T. (2007). *A first course in finite elements*. John Wiley & Sons.
3. Harrach, B. (2021). *An introduction to finite element methods for inverse coefficient problems in elliptic PDEs*. *Jahresbericht der Deutschen Mathematiker-Vereinigung*, 123(3), 183-210.
4. Kwon, Y. W., & Bang, H. (2018). *The finite element method using MATLAB*. Second Edition, Publisher, CRC press.
5. Kurowski, P. M. (2022). *Finite element analysis for design engineers*. SAE International.

Graph Theory BS-Mathematics

Course Code: MTH-425

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course has the following objectives. Apply graph theory to solve real-world problems in various fields, including computer science, operations research, network design, social network analysis, and optimization.

Learning Outcomes

- Develop critical thinking and problem-solving skills by working on graph theory puzzles and applications. Enhance mathematical reasoning and abstract thinking abilities through graph theory concepts and proofs.
- Use graph theory to model and analyze biological networks, such as protein-protein interactions, gene regulatory networks, and metabolic pathways, aiding in drug design and understanding disease mechanisms.

Course Outlines

Unit 1. Basics of Graph Theory

Definitions and Preliminaries of graph. Examples of graph.

Unit 2. Types of Graph

Sub graph. Types of graphs. paths, cycles, wheels and walks, connected and disconnected Graph.

Unit 3. Mappings and Representation

Isomorphism. Handshaking lemma. Matrix representation of a graph

Unit 4. Connected Graphs

Three puzzles. Connectivity. Eulerian graphs. Hamiltonian graphs.

Unit 5. Paths and Trees

Shortest path algorithms, trees.

Recommended Books/Reference Material

1. Gross, J. L., Yellen, J., & Anderson, M. (2018). *Graph theory and its applications*, a. Springer.
2. Lind, D., & Marcus, B. (2021). *An introduction to symbolic dynamics and coding*. a. Cambridge university press.
3. Marcus, D. A. (2020). *Graph theory* , American Mathematical Soc.
4. Trinajstić, N. (2018). *Chemical graph theory*. Routledge.

Programming with MATLAB

BS-Mathematics

Course Code: MTH-426

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objectives are to write programs to solve engineering problems using MATLAB and develop skills to analyze, decompose, and solve engineering problems algorithmically with MATLAB.

Learning Outcomes

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

Understand various matlab programming constructs and their applications in computational problem solving.

Course Outline:

Unit1. Introduction to MATLAB

MATLAB interface, Command Window, user input and output, Arithmetic, variables, operators and expressions, Errors in Input, Vectors and Matrices, Functions: Built-in Functions, User- Defined Functions. Graphics: two-dimensional plots, three-dimensional plot. Calculus with MATLAB Differentiation, Integration, Limits Sums and Products, Taylor Series.

Unit2. Matlab Programming

Logical Operators, M-Files, Script M-Files, Function M-Files, Flow control: if statement, While loops, break, continue, For loops, Nested Loops,

Unit3. Array and Functions

Functions, Built in Functions, Array , Types of Arrays

Unit4 Numerical Methods using MATLAB

Bisection method, Newton-Raphson method, Secant method and Regular Falsi method for non- linear equations. Jacobis iterative method, Gauss-Seidel method for system of linear equations.

Unit5 Numerical Integration and Differentiation Methods using MATLAB

Rectangular rule, Trapezoidal rule, Simpsons rule, Booles rule and Weddles rule for numerical integration. Eulers, improved Euler's, modified Euler's and Runge-Kutta methods for ordinary differential equations.

Recommended Books/Reference Material

1. Gilat, A. and Subramaniam, V., *Numerical Methods with MATLAB*, Wiley, 2011.
2. Gupta, A.K., *Numerical Methods using MATLAB*, Springer, 2014.
3. Herniter, M.E., *Programming in MATLAB*, Cengage Learning, 2000.
4. Hunt, B.R., Lipsman, R. L. and Rosenberg, J. M., *A Guide to MATLAB*, Cambridge University Press, 2006.
5. Mathews, K. D. and Fink, J. H., *Numerical Methods Using MATLAB*, Prentice Hall, 1998.

Programming with MATLAB (Lab)

BS-Mathematics

Course Code: MTH-426L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objectives are to write programs to solve engineering problems using MATLAB and develop skills to analyze, decompose, and solve engineering problems algorithmically with MATLAB.

Learning Outcomes

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

Understand various matlab programming constructs and their applications in computational problem

solving.

Course Outline:

Unit1. Implementation of MATLAB

MATLAB interface, Command Window, user input and output, Arithmetic, variables, operators and expressions, Errors in Input, Vectors and Matrices, Functions: Built-in Functions, User-Defined Functions. Graphics: two-dimensional plots, three-dimensional plot. Calculus with MATLAB Differentiation, Integration, Limits Sums and Products, Taylor Series.

Unit2. Matlab Programming Lab

Logical Operators, M-Files, Script M-Files, Function M-Files, Flow control: if statement, While loops, break, continue, For loops, Nested Loops,

Unit3. Array and Functions Implementation on Computer

Functions, Built in Functions, Array , Types of Arrays

Unit4 Numerical Methods Lab using MATLAB

Bisection method, Newton-Raphson method, Secant method and Regular Falsi method for non-linear equations. Jacobis iterative method, Gauss-Seidel method for system of linear equations.

Unit5 Numerical Integration and Differentiation Methods Lab using MATLAB

Rectangular rule, Trapezoidal rule, Simpsons rule, Booles rule and Weddles rule for numerical integration. Eulers, improved Euler's, modified Euler's and Runge-Kutta methods for ordinary differential equations.

Recommended Books/Reference Material

1. Gilat, A. and Subramaniam, V., *Numerical Methods with MATLAB*, Wiley, 2011.
2. Gupta, A.K., *Numerical Methods using MATLAB*, Springer, 2014.
3. Herniter, M.E., *Programming in MATLAB*, Cengage Learning, 2000.
4. Hunt, B.R., Lipsman, R. L. and Rosenberg, J. M., *A Guide to MATLAB*, Cambridge University Press, 2006.
5. Mathews, K. D. and Fink, J. H., *Numerical Methods Using MATLAB*, Prentice Hall, 1998.

Mathematical Programming in Python

BS-Mathematics

Course Code: MTH-427

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objectives are to understand fundamental Python programming concepts and efficiently use development environments for mathematical programming.

Learning Outcomes

After completion of this course, students should be able to

- Master fundamental Python programming concepts and efficiently use development Environments for mathematical programming.
- Utilize libraries such as Matplotlib, NumPy, SciPy, SymPy and Pandas to perform and visualize advanced mathematical computations.
- Apply mathematical programming techniques to analyze and solve real-world problems.

Course Contents

Unit1 Basics of Python Programming

History of Python, Overview of mathematical programming, Installing and using a Python development environment (Jupyter note book/CoLab). Python syntax and semantics, Data types and variables Control structures (loops, conditionals), functions, Modules and packages.

Unit2 Container Types

Lists, Arrays, Tuples, Dictionaries, Sets, Container conversions.

Unit3 Python Libraries for Data Science

The matplotlib Library: Basic plotting with Matplotlib, Customizing plots (titles, labels, legends), Subplots and multiple plots 3D plotting and other advanced visualizations.

The numpy Library: NumPy arrays and operations, Mathematical functions in NumPy, Array manipulations and broadcasting, Linear algebra operations with NumPy, Universal functions.

Unit4 Python modules for Data Science

The scipy Library: Key submodules in SciPy (optimize, integrate, interpolate, etc.), Numerical integration, Interpolation techniques, optimization problems, Differential equations.

The sympy Library: Basic elements of SymPy, Symbolic Linear Algebra, Calculus with sympy, Graphics in sympy, Three dimensional Graphs.

Unit5 Python Data Frames

The Pandas Library: Series and Data Frames, Data manipulation and cleaning with Pandas, Merging, joining, and concatenating Data Frames, Grouping and aggregating data.

Unit6 Applications

Probability & Statistics, Differential Calculus, Linear Algebra.

Recommended Books/Reference Material

1. Dietel, P. and Dietel, H., *Python for Programmers*, Pearson, 2019.
2. Führer, C., J. E. Solem, and Verdier, O., *Scientific Computing with Python 3*, Packt Publishing, 2021.
3. Johansson, R., Urayasu-shi, Chiba, *Numerical Python*, Pearson, 2017.
4. Hazrat, R., *A Course in Python*, Springer, 2023.
5. Seroul, R., *Programming for Mathematicians*, Springer, 2000.

Mathematical Programming in Python (Lab)

BS-Mathematics

Course Code: MTH-427L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objectives are to understand fundamental Python programming concepts and efficiently use development environments for mathematical programming.

Learning Outcomes

- After completion of this course, students should be able to
- Master fundamental Python programming concepts and efficiently use development environments for mathematical programming.
 - Utilize libraries such as Matplotlib, NumPy, SciPy, SymPy and Pandas to perform and visualize advanced mathematical computations.
 - Apply mathematical programming techniques to analyze and solve real-world problems.

Course Contents

Unit1. Basics of Python Programming Lab

Installing and using a Python development environment (Jupyter note book/CoLab).
Python syntax and semantics, Data types and variables Control structures (loops, conditionals), functions, Modules and packages.

Unit2. Computer Implementation on Container Types

Lists, Arrays, Tuples, Dictionaries, Sets, Container conversions.

Unit3. Computer Lab on Python Libraries for Data Science

The matplotlib Library: Basic plotting with Matplotlib, Customizing plots (titles, labels, legends), Subplots and multiple plots 3D plotting and other advanced visualizations.

The numpy Library: NumPy arrays and operations, Mathematical functions in NumPy, Array manipulations and broadcasting, Linear algebra operations with NumPy, Universal functions.

Unit4. Python modules for Data Science

The scipy Library: Key submodules in SciPy (optimize, integrate, interpolate, etc.), Numerical integration, Interpolation techniques, optimization problems, Differential equations.

The sympy Library: Basic elements of SymPy, Symbolic Linear Algebra, Calculus with sympy, Graphics in sympy, Three dimensional Graphs.

Unit5. Python Data Frames

The Pandas Library: Series and Data Frames, Data manipulation and cleaning with Pandas, Merging, joining, and concatenating Data Frames, Grouping and aggregating data.

Unit6. Applications

Probability & Statistics, Differential Calculus, Linear Algebra.

Recommended Books/Reference Material

1. Dietel, P. and Dietel, H., *Python for Programmers*, Pearson, 2019.
2. Führer, C., J. E. Solem, and Verdier, O., *Scientific Computing with Python 3*, Packt Publishing, 2021.
3. Johansson, R., Urayasu-shi, Chiba, *Numerical Python*, Pearson, 2017.
4. Hazrat, R., *A Course in Python*, Springer, 2023.
5. Seroul, R., *Programming for Mathematicians*, Springer, 2000.

Industrial Mathematics

BS-Mathematics

Course Code: MTH -428

Credit Hours: 03

Pre-requisite: Nil

Objectives

Apply mathematical modeling techniques to represent and analyze real-world industrial problems involving processes such as production, logistics, resource management, and optimization.

Learning Outcomes

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

- Understand and implement numerical methods to find approximate solutions where analytical methods are not feasible, using tools relevant to industry standards.
- Analyze and interpret data using statistical and probabilistic models applicable in quality control, risk analysis, and decision-making.
- Communicate mathematical findings effectively, both in written and oral formats, tailored to technical and non-technical audiences in an industrial context.
- Recognize the limitations of mathematical models and critically evaluate the assumptions and results within the framework of industrial applications.

Course Outline

Unit1. Concepts and Methods of Mathematical Modeling

Basics of Mathematical Modelling. Methodologies of mathematical modeling, statistical data analysis,

Unit2. Optimization and Mathematical Techniques

Mathematical optimization studies as mathematical common languages supporting interdisciplinary viewpoints and design thinking for resolving complex problems in physical and technical processes in industries.

Unit3. Concepts of Industrial Mathematics

The review of various concepts in industrial mathematics used in modeling objects to develop high-angle view points for modeling, and data analysis .

Unit4. Concepts of Industrial Mathematics

Optimization organized as systematic problem-solving methodologies utilizing mathematical modeling.

Unit5. Application

Review of tools and solvers useful for dealing with practical problems. Design Project.

Recommended Books/Reference Material

1. Neunzert, H, Siddiqi, Abul Hasan, (2000), *Topics in Industrial Mathematics: Case Studies and Related Mathematical Methods*, Springer,.

2. Avner Friedman and Walter Littman, (1994), *Industrial Mathematics: A Course in Solving Real-World Problems*, SIAM.
3. Charles R. MacCluer,(2010), *A Survey of Industrial Mathematics*, Dover Publications.

9 List of Mandatory Courses

Sr. No.	Course Code	Course Title	Pre-Requisite	Credit Hours
1	UHQ-101/ ETH-103	Understanding of Holy Quran-I / Ethics-I	Nil	1
2	UHQ-102/ ETH-104	Understanding of Holy Quran-II/ Ethics-II	Nil	1
5	INT-499	Internship	Nil	3
6	CP-498	Capstone Project	Nil	3

10 Course Outlines for Mandatory Courses

Understanding of Quran-I

Course Title: Understanding of Quran - I

Course Code: UHQ-101

Credit Hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plurals through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the Holy Quran.

Course Outline:

Unit 1: Simple Quranic Words

Muallim ul Quran: Book 1: Unit: Lesson 1-19

- Unit 2: Words that comes before (The simple Quranic words)**
Muallim ul Quran: Book 1: Unit#2: Lesson 1-13
- Unit 3: Quranic words in terms of their relationship and characteristics**
Muallim ul Quran: Book 1: Unit#3: Lesson 1-10
- Unit 4: Singular Pronouns**
Muallim ul Quran: Book 2: Unit#4: Lesson 1-17
- Unit 5: Singular pronouns & Demonstrative Pronouns**
Muallim ul Quran: Book 2: Unit#5: Lesson 1-23
- Unit 6: Present Tense**
Muallim ul Quran: Book 3: Unit#6: Lesson 1-5

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ٢٠٢٤. جلد ١، ٢ & ٣

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-I

Course Code: ETH-103

Credit hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nill

Objectives

Upon successful completion if the course, students will be able to know the basics of ethics, & know how develop Ethical approach. Also Analyze the importance of ethic and Ethical values for a human being. And identify the Semitic & Non-Semitic Religions. Moreover, Develop the concept of Ethics in Semitic & Non-Semitic religions. Also, Analyze the similarities and Differences between Ethical teachings of various religions.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the concept of ethics & ethical approach.
- Analyze the difference between the concept of Ethics in Sematic and Non-Sematic religions.

Course Outline:

Unit 1: Introduction and Importance of Ethics & Basic Ethical Principles

Definition of Ethics, Importance of Ethics, Beneficence, Non-maleficence, Autonomy, Justice as basic Ethical behaviors.

Unit 2: Theories of Moral Standards

Moral Standards as Law, Moral Standards as Pleasure, Moral standards as Perfection. (Theories of Various Philosopher such as Kant, Spencer, John S. Mackenzie etc)

Unit 3: The concept of Ethics in Major Religions- Christianity, Judaism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 4: The concept of Ethics in Major Religions- Hinduism & Buddhism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 5: The concept of Ethics in Major Religions- Islam

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

References/Recommended Books:

Books

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
4. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd.Uk.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوۃ المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites & Articles

1. Articles on Ethics www.infotracs-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7 ,2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>

8. Institute for Global Ethics www.globalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). “Philosophical Foundations for Global Journalism Ethics” Journal of Mass Media Ethics:20(1)

Understanding of Quran-II

Course Title: Understanding of Quran - II

Course Code: UHQ-102

Credit Hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nill

Objectives

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammer, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Directly comprehend hundreds of Quranic sentences & verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Course Outline:

Unit 1: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 1: Lesson 1-9

Unit 2: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 2: Lesson 1-7

Unit 3: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 3: Lesson 1-9

Unit 4: Past Tense

Muallim ul Quran: Book 5: Unit#7: Chapter 4: Lesson 1-5

Unit 5: Past Tense & Passive Voice

Muallim ul Quran: Book 5: Unit#7: Chapter 5 - 9

Unit 6: imperative Verbs for Singulars

Muallim ul Quran: Book 6: Unit#8: Lesson 1-8

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ٢٠٢٤. جلد ٣، ٤، ٥، ٦

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-II

Course Code: ETH-104

Credit hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to have better understanding of ethics in various walks of life like in workplace, in business, journalism etc. Moreover, they will be able to be familiarize with Contemporary World's Ethical Issues. And, try to develop answers about them.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the importance of ethics in their lives today.
- Identify Contemporary World's Ethical Issues.
- Create problem solving for these contemporary Ethical issues.

Course Outline:

Unit 1: Professional Ethics & Bioethics

Meaning of Work/Professional Ethics, Professional Ethics and Human Values, Elements of professional Ethics:

Person attitude, Beliefs about work, Positive Attributes (honesty, integrity, dedication, commitment, responsibility, interpersonal relationship)

Genetic engineering, Organ Donation, Cloning, Head Transplant

Unit 2: Ethical Conduct in Business Ethics & it's important

Types of Business Ethics, Common Business Ethical Challenges

Conflict of interest, honesty& integrity, whistle blowing, loyalty vs truth

Unit 3: Journalism

Principles of Ethical Journalism:

Truth & Accuracy, Independence, Fairness & Impartiality, Humanity, Public Accountability

Unit 4: Environmental Ethics

Core Principles of environmental ethics:

Justice & sustainability, Sufficiency & compassion, Solidarity & public participation, Pollution prevention.

Current issues of environmental ethics:

Pollution, The depletion of natural resources, Loss of biodiversity, Destruction of ecosystem, Global climate change

Unit 5: Social Inequalities

Meaning of Social Inequalities, Issues related to social inequality

Difference in source of income, Health care, Freedom of speech, Gender inequality, Toxic workplace culture, Education, Political representation & participation

Unit 6: Social Media Ethics

Facebook, YouTube, WhatsApp, Instagram, TikTok, Snapchat, LinkedIn, X

Current Ethical issues in social media:

Plagiarism, Fake news, Harassment, Photo ethics, Post without caution, inappropriate behavior privacy

References/Recommended Books:

Books

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*,
4. Creative Media Partners, LLC
5. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd.Uk.
6. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوۃ المصنفین، دہلی ۱۹۷۶
7. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites & Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7 ,2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July 2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.gloablethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). “Philosophical Foundations for Global Journalism Ethics” *Journal of Mass Media Ethics*:20(1)

Internship

Course Code **INT-499**

Credit Hours 03

Pre-requisite Nil

Objectives

Enable the student to understand importance and applications of mathematics in real life.

Learning Outcomes

- A math internship is an opportunity for mathematics students to work under the supervision and guidance of professionals in a work environment where they can gain practical experience and apply their academic knowledge to real-world problems.
- Math internships are expansive and provide students with a variety of specializations to consider, depending on their own personal career goals and endeavors. Though the

experiences and responsibilities of each internship vary, most teach global mathematical principles and help interns develop skills in writing, analytics, critical thinking, teamwork, organization and problem-solving.

Course Contents

Institutes where Internship can be availed, Lecture in Schools, Lectures in Colleges, Visits of Bank, Market research internships. Registered Private organizations offering internship. Financial analyst internships. Business intelligence internships. Quantitative research analyst internships.

Capstone Project

Course code: CP-498

Credit hours: 3

Pre-requisite: Nil

Course Objectives

It will enable the student to understand importance and applications of mathematics in real life.

Learning Outcomes

- A capstone project allows students to bring together the concepts, principles and methods that they have learned in their course of study.
- To apply their knowledge and acquired competencies to address the real-world problems.

Course Contents

The capstone project (preferably undertaken after the sixth semester) shall be supervised and graded by a faculty member as per the rules prescribed by the university. This shall be a mandatory degree award requirement of 3 credit hours with course code of CP-499 for all students enrolled in the program.

11 List of General Education Courses

List of Arts and Humanities Courses				
S.NO	Course Code	Course Title	Prerequisite	Credit Hours
1.	BFA-119	History of Ancient Civilizations	Nil	2
2.	BFA-129	Arts and Humanities	Nil	2
3.	ENG-135	English Language	Nil	2
List of Social Sciences Courses				
S. No	Course Code	Course Title	Prerequisite	Credit Hours
1.	SOC-104	Introduction to Social Sciences	Nil	2
List of Natural Sciences Courses				
S.No	Course Code	Course Title	Prerequisite	Credit Hours
1.	PHY-103	Applied Physics	Nil	2
2.	PHY-103L	Applied Physics (Lab)	Nil	1
3.	PHY-105	General Physics	Nil	3
4.	PHY-105L	General Physics	Nil	1
5.	ZOO-123	Cell Biology	Nil	2
6.	ZOO-123L	Cell Biology (Lab)	Nil	1
7.	CHEM-304	Applied Chemistry-I	Nil	2
8.	CHEM-304L	Applied Chemistry-I(Lab)	Nil	1
List of Manadatory Courses				
1	ENG-110	Functional English	Nil	3
2	ENG-111	Expository Writing	Nil	3
3	ISL-101/ ETH-101	Islamic Studies / Ethics	Nil	2

4	MTH-110	Quantitative Reasoning-I	Nil	3
5	STA-112	Quantitative Reasoning-II	Nil	3
6	PAK-103	Ideology and Constitution of Pakistan	Nil	2
7	PAK-104	Pakistan Studies	Nil	2
8	CS-107	Application of Information and Communication Technologies	Nil	2
9	CS-107L	Application of Information and Communication Technologies (Lab)	Nil	1
10	MGT-108	Entrepreneurship	Nil	2
11	CCE-497	Civic and Community Engagement	Nil	2

12 Course Outlines for General Education Courses

History of Ancient Civilizations

Course Code: BFA-119

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will compare and analyse how the accomplishments made by ancient civilizations during their transition still affect our world today. They will also develop understanding about how geography played a role in the development of early civilizations.

Learning Outcomes

- Through understanding, students will be equipped to respect the diversity of contemporary society.
- Upon learning that the environment was a deciding element in the emergence of ancient complex societies, students will be able to realize and uphold a sense of communal, environmental responsibility.

Course Outline

Unit 1. Man, Aesthetic Culture & Civilization

History, Art, Evolution of man: from prehistoric to civilized stance: definition of history, evolution, and civilization. Aesthetic culture of man that differentiates him from all other living beings (Story of ornamentation and anthropology of art). Primitive & Prehistoric culture: Upper, Middle, and Lower eras. 1st civilized stance on the earthen globe (Indus Valley Civilization).

Unit 2. Civilizations (An Overview)

Mesopotamian & Egyptian (An overview of their art and architecture, defining general characteristics and important artifacts). Assignment: Egyptian themed pot painting.

Unit 3. Advanced Civilizations

Greek (Innovations in architecture, sculpture, and painting). Assignment: Geometric designs in 3D forms.

Unit 4. Advanced Civilizations Continued

Roman (Innovations in architecture, sculpture, and painting). Assignment: Mosaic work.

Unit 5. Sub-Continent

Buddhist Art (sculpture and painting; Sanchi, Bharut, Gandhara, and Ajanta. People and their cultural values. Assignment: Study of Signs and Symbols in Buddhist Art.

Recommended Books/Reference Material

1. Blattner. (2012). *World Civilizations and Cultures*, Mark Twain Media.
2. Brown. (2023). *Indian Architecture*. Palmer Press, United States.
3. Edwards. (2023). *Ancient Civilizations of History - Trivia Adventures*. United States.
4. Kleiner, S. (2016). *Gardner's Art Through the Ages, 15th Edition*. Thomson Wadsworth, United States.

Arts and Humanities

Course Code: BFA-129

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will recognize the varying historical, social, political, and economic conditions that shape human action. They will identify how individuals relate to or diverge from particular social norms through the creation of artistic and expressive forms. Students will examine “texts” in any language or structure, and/or art forms in one or more media. They will account for how different worldviews and challenges are expressed in the arts and humanities as a product of interaction among diverse groups.

Learning Outcomes

- Students will gain knowledge in the Arts and Humanities
- Students will engage in complex analysis and reasoning.
- Students will demonstrate media and information literacy.
- Students will communicate effectively.

Course Outline

Unit 1. Criticism, Appreciation and History

What is criticism? What is appreciation? What is History? Comparison between the three. Defining art by different forms of arts: Visual, Performing, Minor, Applied, Plastic Arts, Tiles, Cave art, Music, Dance, Architecture, Painting, Sculpture, Minor arts, literature, etc. Stressing on visual arts. Assignment: Mini sculptures, designing tiles, jewelry making, mosaic.

Unit 2. Appreciation, Meaning of Humanities, Background of Arts

Subject, Function, Medium, Organization, Style and Judgment. Subject: What is it about? Function: what is it for? Medium, very essential: what is it made of? Organization: how is it put together? Style: what is the personality, the individuality of the work? Judgment: how effective is it? Experience, authority, sincerity, humanity. Subject: subject in music, art and nature, art and history, way of presenting the subjects, explanation of the subject, symbol, the irrational, sources of the subject (nature, mythology/religion, history and genre).

Unit 3. Function / Medium

Artist and his medium, techniques, judgment in relation to medium. Organization Plans: (typical, symmetrical, pyramidal, vertical, radical, compound plans), examples from visual arts. Centre of interest: organization of the visual arts, the elements of visual arts.

Unit 4. Art and Culture

Art and Beauty. Art and Religion. Art and Nature. Art and History. Art as an Idea.

Unit 5. Style/ Judgment

Definition, a few characteristics of style, two approaches to study styles, historical style, realism / judgment. Judgment: Sincerity and Sentimentality The problem of judgment. Scope: how much the artist is trying to do? What has he attempted? Levels of meanings. Truth. Magnitude: growth in judgment. Assignment: Working with elements of art.

Recommended Books/Reference Material

1. Davies. (2018) *Definitions of Art*. Cornell University Press, New York.
2. Edwards. (2023). *Ancient Civilizations of History - Trivia Adventures*. United States.
3. Nguyen. (2023). *The Art of Creating:How to Create Art that Transforms Yourself and the World*. One Satori Publishing, United States.
4. Sporre, D. (2015). *Perceiving the Arts: An Introduction to Humanities*. New Jersey, Prentice Hall.

English Language

Course Code: ENG-135

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed for students to introduce them with the evolution of English language over time. This course surveys the development of the English language from its Indo-European past to the present day. It offers a historical study of the English language with particular focus on Old, Middle, and Modern English. It helps understanding the change in English language over time as well as social, political, and other historical conditions related to such changes. Familiarization with the concepts of Language typology and language families will help students understanding the common ancestry of world languages in general and develop their interest in the study of languages in particular. Objective of this course include a comprehension of the mechanisms of language change and an acceptance of the inevitable nature of language change. It aims to gain a knowledge of the origins of English and its place in respect to other languages of the world. It helps an understanding of how the current state of the English language has resulted from historical change

Learning Outcomes

Students who successfully complete this course will demonstrate

- Knowledge of the relationship among languages

- knowledge of general features of Old, Middle and modern English
- knowledge of the principles of etymology and semantic change as well
- an understanding of the social contexts and mechanisms of language change
- awareness of several problems in the origin and nature of language

Course Outline

Unit 1. Introduction

Basic of language, what is Language? The Origin of Language, The divine source, the natural sound source, Oral gesture source. Physiological Adaptations. The Functions of Language. The properties of Language

Unit 2. Language Typology and Language families

Indo-European, Sino-Tibetan, Niger-Congo, Afroasiatic, Austronesian, Altaic, Japonic, Austroasiatic, Tai-Kada. Main Divisions of the Indo-European Group. Indo-Iranian. Armenian and Albanian. Tocharian. Anatolian. Balto-Slavic. Hellenic. Italic. Celtic. Germanic. Cognate words in Indo European Languages. Inflections in Indo European Languages, Verb inflections. Noun inflections, Word Order in Indo European Languages.

Unit 3. The Old English Period (449–1100)

Some Key Events in the Old English Period, History of the Anglo-Saxons, Arrival of Germanic Tribes to the British Isles, Britain before the English, The Coming of the English, The English in Britain, The First Viking Conquest, The Second Viking Conquest, The Scandinavians Become English, The Golden Age of Old English, Dialects of Old English.

Pronunciation and Spelling, Vowels, Consonants, Handwriting, Stress. Vocabulary, the Germanic Word Stock, Gender in Old English. Grammar, Concord, Inflection. Nouns, Umlaut, Modern Survivals of Case and Number. Modifiers, Demonstratives, Adjectives, Adverbs. Pronouns, Personal Pronouns, Interrogative and Relative Pronouns. Verbs, Indicative Forms of Verbs, weak verbs, strong verbs.

Unit 4. The Middle English Period (1100–1500)

Some Key Events in the Middle English Period. The Background of the Norman Conquest. Foreign Influences on Vocabulary. Middle English Spelling, Consonants, Vowels. The Rise of a London Standard, Middle English Vowels, Lengthening and Shortening of Vowels, Leveling of Unstressed Vowels Changes in Grammar, Reduction of Inflections, Loss of Grammatical Gender Nouns, Pronouns, and Adjectives, The Inflection of Nouns, Personal Pronouns, Demonstrative Pronouns, Interrogative and Relative Pronouns, Comparative and Superlative Adjectives. Verbs, Personal Endings, Participles. Word Order.

Unit 5. The Early Modern English Period (1500–1800)

The Transition from Middle to Modern English. Some Key Events in the Early Modern Period, The Renaissance, The Industrial Revolution, British colonialism, Shakespeare's writing (1592-1616) and Elizabethan Era, Coinage of new words

Unit 6. Expansion of the English Vocabulary

Innovation of Pronunciation and Conservation of Spelling. The Orthography of Early Modern English. The Great Vowel Shift. Early Dictionaries. Eighteenth-Century Attitudes toward Grammar and Usage, Nouns, Pronoun, adjective, adverb, verb, preposition.

Unit 7. Late Modern English (1800–Present)

Some Key Events in the Late Modern Period. The National Varieties of English, Conservatism and Innovation in American English, National Differences in Word Choice, American Infiltration of the British Word Stock, Variation within National Varieties. Kinds of Variation, Regional Dialects, Ethnic and Social Dialects, Stylistic Variation, Variation within British English. Varieties of English around the world. The Essential Oneness of All English

Recommended Books/Reference Material

1. Barber C., Beal, J. C., & Shaw, P. A. (2009). *The English language, A historical introduction*. Cambridge University Press.
2. Baugh, A. C., & Cable, T. (2002). *A history of the English language*. Routledge.
3. Blake, N. F. (1996). *A history of the English language* (Vol. 258). London, Macmillan.
4. Brinton, L. J., & Arnovick, L. K. (2006). *The English language, A linguistic history*. Oxford University Press, USA.
5. Bryson, B., Fromkin, V., Rodman, R., Hyams, N., Thorne, S., Trask, R. L., ... & Cran, W. (1991). *The English Language*. Penguin.
6. Daniel, M. (2010). Linguistic typology and the study of language. In *The Oxford handbook of linguistic typology* (pp. 43-68). Oxford University Press.
7. Leith, D., & Jackson, L. (2020). *The origins of English*. In *Changing English* (pp. 39-77). Routledge.
8. Ortiz Colina, R. (2022). *English neologisms in modern times*. Sage.

Introduction to Social Sciences

BS- Sociology

Course Code: SOC-104

Credit Hours: 02

Pre-requisite: Nil

Objectives

Introduction to Social Sciences offers a comprehensive overview of the various disciplines within social sciences, exploring their origins, scope, methodologies, applications, and interconnectedness. Students will be introduced to anthropology, sociology, psychology, political science, economics, geography, and history, with an emphasis on their relevance to contemporary Pakistani society. The course encourages critical thinking, interdisciplinary understanding, and the application of social sciences in real-world contexts.

Learning Outcomes

Upon completion of this course, students will be able to:

- Understand the origins and development of social sciences as distinct fields of study.
- Recognize the scope, methodologies, and principles of various social science disciplines.
- Analyze social phenomena from interdisciplinary perspectives.
- Apply social science concepts to understand and address issues relevant to Pakistani society.
- Engage in critical discussions, research, and ethical considerations within social sciences.

Course Outline

Unit 1. Introduction to Social Science

Definition and Importance of Social Sciences
Historical Development and Interconnectedness

Unit 2. Anthropology

Scope, Methods, and Key Concepts
Cultural and Biological Anthropology

Unit 3. Sociology

Origin and Scope of Sociology
Key Concepts
Sociological Imagination

Unit 4. Psychology

Introduction to Psychology and its Branches
Human Behavior and Mental Processes

Unit 5. Political Science

Understanding Political Systems and Governance
Politics and International Relations

Unit 6. Social Sciences in Pakistani Society

Application of Social Sciences in Pakistani Context
Social Issues, Policies, and Cultural Insights

Unit 7. Research Methods in Social Sciences

Quantitative and Qualitative Research

Unit 8. Interdisciplinary Approaches and Future Trends

Integration of Social Science Disciplines

Emerging Trends and Future Challenges

Recommended Books/Reference Material

1. Colander, D., & Hunt, E. (2022). *Social science: An introduction to the study of society*. Routledge.
2. Gerring, J. (2011). *Social science methodology: A unified framework*. Cambridge University Press.
3. Habermas, J. (2015). *On the logic of the social sciences*. John Wiley & Sons.
4. Sharpes D. K. (2009). *The evolution of the social sciences*. Lexington Books.
5. Williams, M. (2012). *Science and social science: An introduction*. Routledge.

Applied Physics

Course code: PHY-103

Credit Hours: 02

Pre-requisite: Nil

Objectives

The main objective of the course is to provide basic information about Mechanics, Electricity, Magnetism, Electromagnetism, Waves and oscillations, optics, Electronics to the technology students. The course gives the students a sound knowledge of Physics with its applications to problems of practical nature

Learning Outcomes

- Understanding basic concepts of units, vectors, and scalars, along with measurements and uncertainties.
- Application of Newton's laws of motion, work, kinetic energy, and gravitation in various scenarios.
- Exploring electricity concepts, including conductors, insulators, electrostatic force, capacitors, dielectrics, and DC circuits.
- Study of magnetism, covering magnetic fields, force, energy, inductors, and magnetic materials. Additionally, an introduction to semiconductors, including energy levels, hole concept, and PNP/NPN junction transistors and LEDs.

Course Outline

Unit 1. Physics Fundamentals

Basic concept of units, vectors and scalars, measurements and uncertainties, Addition of vectors by graphical and component method. Multiplication of vectors, vectors in three dimensions,

Unit 2. Newton's Laws and Relativity

Newton's laws of motion and their applications, Work and Kinetic Energy, Gravitation, Circular motion, projectile motion, orbits of planets, linear and angular momenta, basic concepts of general and special theory of relativity.

Unit 3. Electricity

Conductors and Insulators, Electrostatic Force, Capacitors and Dielectrics, Capacitance, Energy store in capacitor (Capacitor as memory device), DC Circuits, Measuring V, I, R, RC Circuits.

Unit 4. Magnetism

Magnetic Fields, Magnetic Force, Magnetic Field, Magnetic Field Energy, inductors and inductance, energy stored in inductor (inductor as memory device) magnetic materials.

Unit 5. Semiconductors

Semi-Conductors Energy levels in a semi-conductor, Hole concept, Intrinsic and Extrinsic regions, PNP, NPN junction Transistor, LEDs.

Recommended Books/Reference Material

1. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics*, Extended (12th ed.).
2. Serway, R. A., & Jewett, J. W. (2018). *Physics for Scientists and Engineers* (10th ed.). Cengage Learning.

Applied Physics (Lab)

Course code: PHY-103L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The course objectives are to enable students to comprehend and apply fundamental principles of measurement, elasticity, electrical circuits, and logic gates. They should develop the ability to conduct experiments, analyze data, and manipulate instruments for various measurement and electrical applications, fostering a solid foundation in experimental physics and electronics.

Learning Outcomes

- Demonstrate a solid understanding of fundamental principles in applied physics, including mechanics, thermodynamics, and electromagnetism.
- Apply mathematical and computational techniques to analyze and solve real-world problems in various branches of applied physics.
- Develop practical skills in laboratory experiments, data acquisition, and analysis, enhancing the ability to apply theoretical concepts to hands-on situations.
- Communicate effectively, both orally and in writing, about complex physics concepts, experimental results, and their applications in practical scenarios.

Course Outline**List of Experiments**

1. Study and understand the working principle of Vernier caliper and Screw Gauge.
2. Study Hooke's Law using the mass-spring system, determining the stiffness (k -value) of the spring.
3. Investigate the relationship between the length of a pendulum and its period of oscillation.

4. Determine the internal resistance of a galvanometer using the half deflection method.
5. Experiment with various resistors and voltage sources to verify Ohm's law ($V = IR$) by measuring voltage, current, and resistance in a circuit.
6. Convert a galvanometer into a voltmeter.
7. Convert a galvanometer into an ammeter.
8. Study the series and parallel configurations of capacitors and resistors and verify binary truth tables using logic gates.

Recommended Books/Reference Material

1. Loyd, D. H. (2008). *Physics Laboratory Manual*. Thomson Higher Education.
2. Smith, W. F. (2020). *Experimental Physics: Principles and Practice for the Laboratory*. Taylor and Francis.
3. Wilson, J. D., & Hernández-Hall, C. A. (2014). *Physics Laboratory Experiments*. Cengage Learning.

Cell Biology

Course Code: ZOO-123

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will acquire knowledge about the basic concepts of cell biology. They will learn about the cellular structure, composition of the organelles, cell growth and cellular division. They will know about how macromolecules and organelles govern the dynamic organization, function of living cells.

Learning Outcomes

- Students will acquire the basic concepts of cell biology.
- Students will understand the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.
- Students will have the ability to understand the role of macromolecules regulating cellular processes.

Course Outline

Unit 1. Cell Structure and Function

Cell theory. Comparison of plant and animal cells. Comparison of prokaryotic and eukaryotic cells. Structural models of cell membrane. Chemical composition of cell membrane and its function

Unit 2. Cell Organelles

Endoplasmic reticulum. Golgi Bodies. Mitochondria. Lysosomes. Peroxisomes. Ribosome

Unit 3. Nucleus

Structure and function. Nuclear membrane. Chromatin

Unit 4. Cytoskeleton

Structure and types. Functions of cytoskeleton

Unit 5. Cellular Transport

Diffusion and osmosis. Facilitated and active transport. Endocytosis and exocytosis

Unit 6. Cellular Reproduction

Cell cycle. Mitosis. Meiosis

Recommended Books/Reference Material

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. (2017). *Molecular biology of the cell*. 6th Edition. Garland science.
2. De Robertis, E. D. P. (2017). *Cell and Molecular Biology*. 8th edition, Lea & Febiger, New York.
3. Geoffrey M.C., Robert E.H. (2007). *The cell: A Molecular Approach*. Sinauer Associates, INC.
4. Karp, J. (2005). *Cell and Molecular Biology, Concepts and Experiments*. Jhon Wiley and Sons, INC.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. C. (2016). *Molecular Cell Biology*. Macmillan Higher Education..
3. Miller, S.A. and Harley, J.B. (2014). *Zoology*. 12th Ed. (International),Singapore: McGraw-Hill

Cell Biology (Lab)

Course Code: ZOO-123L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Students will acquire knowledge about the basic staining techniques. They will learn about the identification of cell organelles. They will know about the different stages of mitosis and meiosis.

Learning Outcomes

- Students will be able to identify the prepared slides of different cell organelles.
- Students will be able to know the techniques of preparation of whole mount.
- Students will understand the different stages of cell cycle

Course Outline

- 1.Study of microscope.
2. Study of staining techniques (Gram staining).
3. Study of prepared slides of cell organelles.

4. Preparation of temporary whole mount.
5. Preparation of permanent whole mount.
6. Squash preparation of onion root tip for mitotic stages.
7. Study of mitotic and meiotic stages with the help of prepared slides.

Recommended Books/Reference Material

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. (2017). *Molecular biology of the cell*. 6th Edition. Garland science.
2. De Robertis, E. D. P. (2017). *Cell and Molecular Biology*. 8th edition, Lea & Febiger, New York.
3. Geoffrey M.C., Robert E.H. (2007). *The cell: A Molecular Approach*. Sinauer Associates, INC.
4. Karp, J. (2005). *Cell and Molecular Biology, Concepts and Experiments*. Jhon Wiley and Sons, INC.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. C. (2016). *Molecular Cell Biology*. Macmillan Higher Education..
6. Miller, S.A. and Harley, J.B. (2014). *Zoology*. 12th Ed. (International), Singapore: McGraw-Hill.

Applied Chemistry-I

Course Code: CHM-304

Credit Hours: 02

Pre-requisite: Nil

Objectives

After studying this course the student will be able to tell: Analytical Separations: Masking, Precipitation and Filtration, Solvent Extraction. Chromatography. Electrophoresis Thermal Analysis. Thermogravimetry. Differential Thermal Analysis. Differential Scanning Calorimetry. Thermo-Mechanical Analysis.

Learning Outcomes

Students will have comprehensive knowledge about:

- Different techniques of Analytical Separations i.e., Masking, Precipitation and Filtration, solvent Extraction.
- Chromatograph Electrophoresis, Thermal Analysis,
- Thermogravimetry, Differential Thermal Analysis, Differential Scanning Calorimetric & thermo-Mechanical Analysis.

Course Outline

- Unit 1. **Introduction to Analytical Separations**
 Introduction to Analytical Separations
 Masking, Precipitation and Filtration

- Unit 2. Introduction to Analytical Separation Techniques
Solvent Extraction, Distribution law, Introduction and theory of chromatography, Types of chromatography
- Unit 3. Chromatography
HPLC and GC
HPTC, Ion exchange chromatography
- Unit 4. Electrophoresis
Introduction to electrophoresis, Principle and instrumentation of capillary electrophoresis, sampling, detection, TGA, DTA + Ion pair chromatography
- Unit 5. Thermomechanical Analysis
Differential Scanning Calorimetry, Thermo-Mechanical Analysis.

Recommended Books/Reference Material

1. Anju. Rawlley., Devdetta. V.S., (2022), Applied Chemistry. Khana Book Publishing Co(P) Ltd.
2. Douglas A. S., Donald. M. W., James.H.(2003), *Fundamentals of Analytical Chemistry*, (8th ed.). Saunders College Publishing, Philadelphia.
3. Gary D. Christian. (2004), *Analytical Chemistry*, (6th ed.), John Wiley & Sons, Inc.
4. Hobert.H., Willard, D.L. (1988). *Instrumental Methods of Analysis*, (7th ed.), Wadsworth Publishing Company.
5. Maris.T., (2021), *Materials Science and Applied Chemistry IV*, Trans tech publishers Limited.

Applied Chemistry-I (Lab)

Course Code: CHM-304L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Students will acquire understanding about the analytical separations, masking, precipitation and filtration. Solvent Extraction, Chromatography, Electrophoresis. Thermal analysis, Thermogravimetry, differential thermal analysis. Differential scanning calorimetry, thermomechanical analysis.

Learning Outcomes

- Students will have comprehensive knowledge about different techniques of Analytical Separations i.e., Masking, Precipitation and Filtration, Solvent Extraction, Chromatograph Electrophoresis, Thermal Analysis, Thermogravimetry, Differential Thermal Analysis, Differential Scanning Calorimetry & Thermo-Mechanical Analysis.

Course Outline

- Measurement of water hardness by EDTA titration.
- Estimation of total solids in water
- Estimation of chlorides in water
- Redox titration: estimation of ferrous and ferric ion in drinking water.
- Extraction of capsicum oil (soxhlet extraction)
- Extraction of clove oil from clove
- Study of kinetics of dissolution of Mg metal in dilute HCL.
- Estimation of Mg in steel or estimation of ferric ion in cement.

Recommended Books/Reference Material

1. Anju.Rawlley., Devdetta. V.S., (2022), *Applied Chemistry*, Khana Book Publishing Co(P) Ltd.
2. Douglas A. S., Donald. M. W., James.H.(2003), *Fundamentals of Analytical Chemistry*,(8th ed.). Saunders College Publishing, Philadelphia.
3. Gary D. Christian.(2004), *Analytical Chemistry*, (6th ed.), John Wiley & Sons, Inc.
4. Hobert.H., .Willard.D.L.,(1988), *Instrumental Methods of Analysis*,(7th ed.), Wadsworth Publishing Company.
5. Maris.T., (2021), *Materials Science and Applied Chemistry IV*, Trans tech publishers Limited.

Functional English

Course Code: ENG-110

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and communication aspects including professional writing, public speaking, and everyday conversation. Ensuring that students are equipped in both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with case and efficacy, making a positive impact hi their functional interactions.

Learning Outcomes

- Apply enhanced English communication skills through effective use of word choices, grammar and sentence structure.
- Comprehend a variety of literary non-literary written and spoken texts in English.
- Effectively express information, ideas and opinions in written and spoken English.
- Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

Course Outline

Unit 1. Introduction

Ice breaking Activities. Types and modes of Communication. Intrapersonal, intra-personal and group communication.

Unit 2. Rules for Structure of Sentences

Types of sentences. Punctuation and Spelling, Vocabulary. Lexical and functional categories. Structural kind of sentences: simple, compound, complex. Synthesis of sentences.

Unit 3. Concept of Time and Tense (present, past, future).

Discussion: General topics and everyday conversation. Concept of Voice: active and passive voice. Functional use of Voice in different situations. Discussion: General topics and everyday conversation.

Unit 4. Direct and Indirect Reporting.

Discussion: General topics and everyday conversation, describing things persons, places, pictures, events etc. Salutation & Greeting, Introduction, Asking and answering questions. Discussion: General topics and everyday conversation.

Unit 5. Practicing Everyday Conversation

Request and Permission, Agreement and Disagreement. Apologizing, Expressing likes and Dislikes, expressing opinion. Expressing approval, Disapproval, Discussion: General topics and everyday conversation.

Unit 6. Articulating Expression

Expressing appreciation, regret, and indifference. Expressing certainty, uncertainty, and obligation. Expressing suggestion, warning, Expressing possibility, impossibility & logical conclusion. Discussion: General topics and everyday conversation.

Unit 7. Art of Inviting

Accepting, declining invitation. Expressing & inquiring about preferences. Stating intentions and Making Plans. Giving directions. Instructing people how to do things.

Unit 8. Discussing Past and Present

Future prospects. Talking about the past.

Recommended books/ Reference material

1. Azar, B. S. (2003). *Fundamentals of English grammar*. Longman.
2. Beebe, S. A., Beebe, S. J., & Ivy, D. K. (2010). *Communication: Principles for a lifetime* (p. 483). Boston, MA: Allyn & Bacon.
3. Eastwood, J. (1994). *Oxford guide to English grammar*. Oxford University Press.
4. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.)
5. Kortmann, B. (2020). *English linguistics: essentials*. Springer Nature.
6. Langan, J. (2001). *College writing skills with readings*. New York.
7. Murphy, R. (2003). *English grammar in use*. Cambridge: Cambridge University Press.
8. Sharma, Gajendra Dutt (2023) *A Comprehensive Resource Book of Functional English*, OEP, New Delhi.
9. Thomson, A. J., & Martinet, A. V. (2015). *A practical English grammar*. New York: Oxford University Press.
10. Wren, P. C., & Martin, H. (2000). *English grammar and Composition*. New Delhi: S Chand & Company Ltd.

Expository Writing

Course Code: ENG-111

Credit Hours: 03

Pre-requisite: Nil

Objectives

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation building pre-requisite course, Functional English, this course will enhance students' basic skills of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

Learning Outcomes

- Understand the essentials of the writing process integrating pre-working, drafting, editing and proofreading to produce well-structured essays.
- Uphold ethical practices to maintain originality in expository writing.

Course Outline

Unit 1. Introduction to Expository Writing

Understanding expository writing (definition, types, purpose and applications).

Characteristics of effective expository writing (clarity, coherence and organization).

Introduction to paragraph writing.

Unit 2. The Writing Process

Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.). Drafting (three stage process of drafting techniques). Revising and editing (ensuring correct grammar, Clarity, coherence, conciseness etc.). Proofreading (fine-tuning of the draft). Peer review and feedback (providing and receiving critique).

Unit 3. Essay Organization and Structure

Introduction and hook (engaging readers and introducing the topic). Thesis statement (crafting a clear and focused central idea). Body Paragraphs (topic sentences, supporting evidence and transitional devices). Conclusion (types of concluding paragraphs and leaving an impact). Ensuring cohesion and coherence (creating seamless connections between paragraphs)

Unit 4. Types of Expository Writing

Description, Illustration, Classification. Cause and effect (exploring causal relationships and outcomes). Process analysis (explaining step-by-step procedures). Comparative analysis (analyzing similarities and differences)

Unit 5. Writing for Specific Purposes and Audiences

Different types of purposes (to inform, to analyze, to persuade, to entertain etc.). Writing for academic audiences (formality, objectivity, and academic conventions). Writing for public audiences (engaging, informative and persuasive language). Different tones and styles for specific purposes and audiences.

Unit 6. Ethical Considerations

Ensuring original writing (finding credible sources, evaluating information etc.). Proper citation and referencing (APA, MLA, or other citation styles). Integrating quotes and evidences (quoting, paraphrasing, and summarizing). Avoiding plagiarism (ethical considerations and best practices)

Recommended Books/ Reference Material

1. Axelrod, R. B., & Cooper, C. R. (2010). *The St. Martin's guide to writing*. Macmillan.
2. Faigley, L., Selzer, J., Enoch, J., & Wible, S. (2009). *Good reasons with contemporary arguments*. Pearson Longman.

3. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.
4. Graff, G., Birkenstein, C., & Maxwell, C. (2014). *They say, I say: The moves that matter in academic writing* (p. 245). Gildan Media Corp Book Publisher.
5. Johnson-Sheehan, R., Paine, C., & Paine, C. (2010). *Writing today*. Pearson Education India.
6. Keizer, E. (2015). *A functional discourse grammar for English*. Oxford University Press.
7. Rosenwasser, D., & Stephen, J. (2011). *Writing analytically*. Cengage Learning Press.
8. Straaijer, R. (2018). Modern English usage from Britain to America: Bryan Garner follows Henry Fowler from A Dictionary of Modern American English Usage to Garner's Modern English Usage. *English Today*, 34(4), 39-47.
9. Wachal, R. S. (2000). The Elements of Style, by William Strunk, Jr., and EB White; and A Dictionary of Modern American Usage, by Bryan A. Garner. *American speech*, 75(2), 199-207.
10. Williams, J. M., & Bizup, J. (2022). *Lessons in clarity and grace*. Pearson.

Islamic Studies

Course Code: ISL-101

Credit Hours: 02

Pre-Requisites: Nil

Objectives

Students will be able to demonstrate enhanced knowledge of Islamic Fundamentals, beliefs, practices, historical development, spiritual values and Ethical Principles. Describe Basic sources of Islamic Law and their application in daily life. Also, Identify and discuss contemporary issues being faced by the Muslim world Including Social Challenges, Gender Role and Interfaith dialogue.

Learning Outcomes

- Evaluate and discuss their understanding about the beliefs, history and Ethical values of Islam.
- Be able to apply and relate the Articles of faith in their life according to present world.
- Be able to analyze the importance of Quran and Sunnah in their life and also to refute many relating misconceptions
- Engage in Discussions and write about Contemporary issues specifically related to Women.

Course Outline

Unit 1. Introduction to Islam

Definition of Islam and its core Beliefs (Tawheed, Akhirat and Risalat), Pillars of Islam and their significance (Tawheed, Prayers, Fasting, Zakat & Hajj), The Holy Quran (Introduction, Revelation & Compilation), Sunnah & Hadith (Introduction, Revelation & Compilation)

Unit 2. Seerah of the Holy Prophet pbuh

Life of Prophet pbuh in Makkah, Life of Holy Prophet pbuh in Medina, Diverse roles of Holy Prophet pbuh (individual, leader, peacemaker, educator etc)

Unit 3. Islamic History and Civilization

World before Islam, The Rashidun Caliphate and its expansion, Contributions of Muslim Scientists and Philosophers.

Unit 4. Islamic Jurisprudence

Fundamental sources of Islamic Jurisprudence, Major Schools of Islamic Jurisprudence, Significance & principle of Ijtihad

Unit 5. Family & Society in Islam

Status and Rights of Women in Islam, Marriage, Family & Gender roles in Muslim Society, Family values and Structure in Muslim Society

Unit 6. Islam & Modern world

Relevance of Islam in Modern World. (Islamophobia, Interfaith dialogue & Multiculturalism), Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books/Reference Material

1. Ahmed, Dr. A. (1996). *Women & Social Justice: An Islamic Paradigm*, The Islamic Foundation UK
2. Ahmed, K. (1971) *Islami Nazria e Hayat*, Karachi University press.
3. Ahmed, K. (1980). *Islam, Its meaning & message*, The Islamic Foundation UK.
4. Al-Mubarikpuri, M. S. (2002), *Al Raheeq ul Makhtoom (The Sealed Nector)*, Dar ul Salam.
5. Al-Suhaym, Dr. M.B., A. (2006) *Islam, Its foundation & concepts*, Darussalam
6. An Introduction to Islamic Theology by John Renard.
7. Bokhari, A.S, Zafar, M.D., Prof. Shakir, A.S. (2021). *A textbook of Islamic Education*, Akram Printing Press, Lahore.
8. Hussain, M. *The Five Pillars of Islam: A Framework for Islamic Values and Character building*, Kube Publishing, The Islamic Foundation UK
9. Maududi, Abul A. (2008). *Islamic Civilization Foundations, Beliefs & Principles*, Kube Publishing, Islamic Foundation UK
10. Maududi, Abul. A. (2007). *Towards understanding Islam*, The Islamic foundation UK
11. Phillip, Dr. A. A., B. (2018) *Islamic Studies*, International Islamic Publishing House.
12. Prof. Dr. Chaudary, M.N., Prof. Malik, M.A (2022). *Tafheem e Islamiyat*, Qureshi Brothers Publishers, Lahore.

Ethics (in lieu of Islamic Studies)

Course Code: ETH-101

Course Title: Ethics

Credit Hours: 2

Pre-Requisite: Nil

Objectives

Upon successful completion of the course, students will be able to know the basics of Ethics & Morality and develop Ethical approach, Identify the concept of Ethics in Different Religions & Relate the ethical values with their lives business ethics, journalism ethics etc.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the meaning of Ethics and Morality.
- Analyze the Similarities and Differences between ethical teachings of various religions.
- Develop sense of belongingness to the ethical values as a student, being member of the society etc.

Course Outline:

Unit 1. Meaning and Scope of Ethics

Meaning and Definition of Ethics and Morality, Difference between Ethics and Morality, Relation of Ethics with: Religion, Science, Law.

Unit 2. Historical development of Morality

Instinctive Moral Life, Customary Morality, Reflective Morality.

Unit 3. Moral Theories, Moral Ethics and Society

Hedonism (Mill), Intuitionism (Butler), Kant's Moral Theory, Freedom and Responsibility, Tolerance, Justice, Punishment.

Unit 4. Moral Teaching of Major Religions

Judaism, Christianity, Islam, Islam and Minorities.

Unit 5. Professional Ethics

Medical Ethics, Ethics of Student, Ethics of Teacher, Business Ethics.

Recommended Books/ Reference Material

1. R. Shafer-Landau. (2020). *The Fundamentals of Ethics*, 5th Edition.
2. S. Blackburn. (2021). *Ethics: A Very Short Introduction (Very Short Introductions)* 2nd Edition.
3. S. Liautaud, L. Sweetingham. (2022). *The Power of Ethics: How to Make Good Choices in a Complicated World*.
4. S. M. Cahn, P. Markie. (2019). *Ethics: History, Theory, and Contemporary Issues*, 7th Edition.

Department: Mathematics

Quantitative Reasoning-I

Course Code: MTH-110

Pre-requisite: Nil

Credit Hours: 03

Objectives

Quantitative Reasoning-I is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

Learning Outcomes

By the end of this course

- The students shall have fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately.
- Understanding of fundamental mathematical concepts. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

Course Outline

Unit 1. Numerical Literacy

Number system and basic arithmetic operations. Units and their conversions, dimensions, area, perimeter and volume. Rates, ratios, proportions and percentages. Types and sources of data; Measurement scales. Tabular and graphical presentation of data. Quantitative reasoning exercises using number knowledge.

Unit 2. Fundamental Mathematical Concepts

Basics of geometry (lines, angles, circles, polygons etc. Relations, functions, and their graphs. Exponents, factoring and simplifying algebraic expressions. Algebraic and graphical solutions of linear and quadratic equations and inequalities. Quantitative reasoning exercises using fundamental mathematical concepts.

Unit 3. Mathematical Modeling and Analyses

Introduction to deterministic models. Use of linear functions for modeling in real-world situations. Modeling with the system of linear equations and their solutions. Elementary introduction to derivatives in mathematical modeling. Linear and exponential growth and decay models. Quantitative reasoning exercises using mathematical modeling.

Unit 4. Introduction to Logic

Introduction and importance of logic. Inductive, deductive and abductive approaches of reasoning. Propositions, arguments (valid, invalid), logical connectives.

Unit 5. Truth Tables and Logical Reasoning Concepts

Truth tables and propositional equivalences. Logical fallacies. Venn Diagrams. Predicates and quantifiers. Quantitative reasoning exercises using logical reasoning concepts and techniques.

Recommended Books/Reference Books

1. Bennett, J., & Briggs, W.L and Badalamenti. A. (2019). Using and understanding mathematics: A quantitative reasoning approach. Pearson.
2. Mesquita, E.B., and Fowler, A. (2021). Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis. Princeton University Press.
3. Rosen, K. H. (2007). Discrete mathematics and its applications. The McGraw Hill Companies.
4. Schröder, B. (2010). Fundamentals of Mathematics. Wiley.
5. Zaslow, E. (2020). Quantitative Reasoning: Thinking in Numbers. Cambridge University Press.

Quantitative Reasoning-II

Course Code: STA-112

Credit Hours: 03

Pre-requisite: Nil

Objectives

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of other sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. The course also focuses on basic principles of probability and distributions, regression and correlation analysis, estimation and testing of hypothesis. It will prepare students to apply the quantitative reasoning skills in solving quantitative problems which they will experience in their practical lives.

Learning Outcomes

- Student will understand the basic statistical concepts and have basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts and equation etc.
- Understand basic quantitative modeling and analyses.
- Ability to critically evaluate quantitative information to make evidence based decision through appropriate statistical tools.

Course Outline

Unit 1. Introduction of Statistic and Data Condensation

Types and sources of data. Measurement scales. Population and sample. Tabular and graphical presentation of data. Quantitative reasoning exercises using fundamental statistical concepts.

Unit 2. Measure of Central Tendency and Dispersion

Measure of central tendency. Measure of dispersion. Data interpretation. Quantitative reasoning exercises using statistical concepts.

Unit 3. Probability and Probability Distributions

Basic probability theory. Rules of counting (multiplicative, permutation, combinations). Introduction to random variables and their probability distributions. Quantitative reasoning exercises using probability theories and distribution concepts.

Unit 4. Regression and Correlation Analysis

Introduction to probabilistic models. Bivariate analysis. Scatter plots. Simple linear regression model. Correlation analysis. Quantitative reasoning exercises using statistical modelling.

Unit 5. Estimation and Testing of Hypothesis

Basics of estimation and confidence interval. Testing of Hypothesis (z-test; t-test). Statistical inference in decision making. Quantitative reasoning exercises using estimation and Statistical inference concepts and techniques.

Recommended Books/Reference Material

1. Chaudhry S.M., & Kamal. S. (2018). *Introduction to statistical theory part I*. Lahore, Pakistan: Ilmi Kitab Khana.
2. Chaudhry S.M., & Kamal. S. (2018). *Introduction to statistical theory part II*. Lahore, Pakistan: Ilmi Kitab Khana.
3. Hogg, R., Mckean, J., & Craig, A. (2021). *Introduction to mathematical statistics*, (8th ed.). Boston: Pearson Education.
4. Mendenhall, W., Beaver, R. J., & Beaver, B. M. (2012). *Introduction to probability and statistics*. Cengage Learning.
5. Mood, A.M., Graybill, F.A., & Boes, D.C. (1974). *Introduction to the theory of statistics*, (3rd ed.). New York: McGraw Hill.
6. Moore, D. S., McCabe, G.P., & Craig, B. A. (2021). *Introduction to the practice of statistics*, (10th ed.). New York: WH Freeman.
7. Walpole, R. E. (2002). *Introduction to statistics*, (7th ed.). New York: Macmillan publishing company.
8. Walpole, R.E., Myers, R.H., & Myers, S.L. (1998). *Probability and statistics for engineers and scientist*, (6th ed.). New York: Prentice Hall.

Ideology and Constitution of Pakistan

Course Code: PAK-103

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that

have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.

Learning Outcomes

- Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
- Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
- Explain about the guiding principles on rights and responsibilities of Pakistani citizens are enshrined in the Constitution of Pakistan 1973.

Course Outline

Unit 1. Introduction to the Ideology of Pakistan

Definition and significance of ideology. Historical context of the creation of Pakistan (with emphasis on socio-political. Religious and cultural dynamics of British India between 1857 till 1947). Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah etc. Contributions of women and students in the freedom movement or separate homeland.

Unit 2. Two-Nation Theory

Evolution of the Two-Nation Theory (Urdu-Hindi controversy. Partition of Bengal. Simla Deputation 1906, Allama Iqbal Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940). Role of communalism and religious differences.

Unit 3. Introduction to the Constitution of Pakistan

Definition and importance of a constitution. Ideological factors that shaped the Constitution(s) of Pakistan. Overview of constitutional developments in Pakistan.

Unit 4. Constitution and State Structure

Structure of government (executive, legislature, and judiciary). Distribution of powers between federal and provincial governments. Eighteenth Amendment and its impact of federalism.

Unit 5. Fundamental Rights, Principles of Policy and Responsibilities

Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles R-28). Overview of Principles of Policy (Articles 29-40). Responsibilities of the Pakistani citizen.

Unit 6. Constitutional Amendments

Procedures for amending the Constitution. Notable constitutional amendments and their implications.

Recommended Books/Reference Material

1. Ahmed, A. S. (1997). *Jinnah, Pakistan and Islamic Identity: The Search for Saladin*. Routledge.
2. Aziz, K. K. (2002). *The Making of Pakistan: A Study of Nationalism*. Sang-e-Meel Publishers.
3. Choudhury, G. W. (1969). *Constitution-Making in Pakistan: The Dynamics of Political*. Columbia: University of British.
4. Cohen, S. P. (2004). *The Idea of Pakistan*. Washington: Brookings Institution Press.
5. Hussain, M. (2020). *The Parliament of Pakistan*. London: Oxford University press.
6. Iqbal, J. (2005). *Ideology of Pakistan*. Sang-e-Meel.
7. Jalal, A. (2014). *The Struggle for Pakistan: A Muslim Homeland and Global Politics*. Belknap Press: An Imprint of Harvard University Press.
8. Khan, H. (2020). *Constitutional and Political Development of Pakistan*. London: Oxford University Press.
9. Mahmood, S. (2003). *Pakistan: Political Roots and Development*. Sterling: University of Michigan.
10. Mujahid, S. u. (2001). *Ideology of Pakistan*. Progressive Publishers.
11. Qureshi, I. H. (1965). *The Struggle for Pakistan*. Karachi: University of Karachi Press.
12. Sayeed, K. B. (1960). *Pakistan: The Formative Phase*. London: Oxford University Press
13. Talbot, I. (2015). *Pakistan: A New History*. London: Oxford University Press.
14. *The Constitution of Pakistan 1973*. Original text. Retrieved from website: National Assembly: https://na.gov.pk/uploads/documents/1333523681_951.pdf
15. Ziring, L. (2000). *Pakistan in the Twentieth Century: A Political History*. London: Oxford University Press.

Pakistan Studies

Course Code: PAK-104

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

Learning Outcomes

After studying this course, the student will be able to:

- Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
- Understand the society and culture of Pakistan.
- Understand and explain the socio-economic developments in Pakistan.
- Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

Course Outline

Unit 1. Introduction to Pakistan

Geographical location and significance. Historical background: Ancient civilizations in the region. Factors leading to the creation of Pakistan.

Unit 2 Political History of Pakistan

Formative phase. Military interventions and democratic transitions.

Unit 3. Geography of Pakistan

Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas. River systems: Indus River and its tributaries. Climatic regions of Pakistan.

Unit 4. Society and Culture of Pakistan

Socio-cultural diversity. Languages and literature of Pakistan

Unit 5. Economic Development of Pakistan

Agriculture and industrial sectors of Pakistan. Economic challenges of Pakistan.

Unit 6. Contemporary Issues

Foreign relations of Pakistan. Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

Recommended Books/ Reference Material

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan
7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by Ian Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir
11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi

15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan
16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain
20. "Issues in Pakistan's Economy" by S. Zaidi

Application of Information and Communication Technologies

Course Code: CS-107

Credit Hours: 2

Pre-requisite: Nil

Objectives

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes

- Define various types and components of computer including input/output devices, memory, storage media.
- Describe different types of software from operating systems to system utilities and productivity apps.
- Describe the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, and storage media.

Course Outline

Unit 1. Technology

Types of Computers, Mobile & Game Devices, Data and Information, The Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy, Health Concerns, Environmental Issues, Programs and Apps, Operating Systems, Applications, Installing and Running Programs, Developing Programs and Apps,

Communications and Networks, Wired and Wireless Communications, Networks, Technology Uses, Government, Finance, Retail, Entertainment, Health Care, Science, Travel, Publishing, Manufacturing, Technology Users.

Unit 2. Online Web

The Internet, Websites and Media, The Internet, Evolution of the Internet, connecting to the Internet, Internet Service Providers, How Data Travels the Internet, IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit 3. Evaluating Computers and Mobile Devices

Mobile Computers and Desktops, Laptops, Tab and Other Mobile Computers, Handheld Computers, Desktops and All-in-Ones, Servers, Terminals, Point-of-Sale Terminals, Wearable Devices, Game Devices, Embedded Computers. Inside the Case, The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit 4. Programs and Apps

Role of the Operating System, Obtaining Software, Installing Software, Categories of Programs and Apps, Multimedia and Interest Applications, Communications Applications, File, Disk, and System Management Tools.

Unit 5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure. Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). *Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach*. Cengage Learning.
2. Hafez, K., Skinner, A., & Grüne, A. (2022). *Foundations of Global Communication: A Conceptual Handbook*. Routledge.
3. Hawkrige, D. (2022). *New information technology in education*. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2016). *Managing and using information systems: A strategic approach*. John Wiley & Sons.
5. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). *Managing and using information systems: A strategic approach*. John Wiley & Sons.

Application of Information and Communication Technologies (Lab)

Course Code: CS-107L

Credit Hours: 1

Pre-requisite: Nil

Objectives

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes

- Define various types and components of computer including input/output devices, memory, storage media.
- Describe different types of software from operating systems to system utilities and productivity apps.
- Describe the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline

Unit 1. Technology

Introduction to the lab equipment and SOPs of the labs. Introduction to computer hardware and system information. Introduction to the Web, Web Searching,

Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy.

Unit 2. Online Web

IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit 3. Evaluating Computers and Mobile Devices

Inside world: The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit 4. Programs and Apps

File, Disk, and System Management Tools. MS office.

Unit 5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure. Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach. Cengage Learning.
2. Hafez, K., Skinner, A., & Grüne, A. (2022). Foundations of Global Communication: A Conceptual Handbook. Routledge.

3. Hawkrigde, D. (2022). New information technology in education. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2016). Managing and using information systems: A strategic approach. John Wiley & Sons.
5. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). Managing and using information systems: A strategic approach. John Wiley & Sons.

Entrepreneurship

Course Code: MGT-108

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, abilities, enabling them to seize the identified opportunities for initiating ventures and successful navigating the challenges that come with starting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business, market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation.

Learning Outcomes

By the end of this course, students shall have:

- Knowledge of fundamental entrepreneurial concepts, skills and process.
- Understanding on different personal, social and financial aspects associated with entrepreneurial activities.
- Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on export businesses.
- Ability to apply knowledge, skills and competencies acquired in the course to develop a feasible business plan.

Course Outline

Unit 1. Introduction to Entrepreneurship. Opportunity Recognition and Idea Generation, Team Building for Startups

Definition and concept of entrepreneurship. Why to become an entrepreneur? Entrepreneurial process. Role of entrepreneurship in economic development. Opportunity identification, evaluation and exploitation. Difference between Idea

and Opportunity. Innovative idea generation techniques for entrepreneurial ventures. Characteristics and features of effective teams. Team building and effective leadership for startups.

Unit 2. Feasibility analysis and Entrepreneurial Skills

Product/ service feasibility. Industry/ market feasibility. Organizational feasibility. Financial feasibility/ risk assessment. Characteristics and qualities of successful entrepreneurs (including stories of successes and failures). Areas of essential entrepreneurial skill and ability such as creative and critical thinking, innovation and risk-taking abilities etc.

Unit 3. Developing An Effective Business Model, Writing Business Plan

Standard Business Model. Disruptive Business Model. Barringer Model Characteristics. Business Plan as an entrepreneur. Industry and Competitor analysis. Five forces porter model

Unit 4. Preparing Ethical and Legal Foundation

Strong ethical culture in their entrepreneurial ventures. Deal with legal issues. Business licenses and permits that a start-up must obtain before it begins operating. Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.). Legal Status of Entrepreneurial firm. Intellectual property rights and protection. Business method patents. Trademarks. Copyrights. Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms. Identify and describe the different forms of organization available to new firms

Unit 5. Production Plan, Marketing and Sales

Raw material, Utilities and Manpower, Plant and Machinery, Lay out and location. Target market identification and segmentation; Four Ps of Marketing. Developing a Marketing Strategy. Unique Marketing Issues Explain the three steps (segmenting the market, selecting a target market, and establishing a unique marketing position) entrepreneurial firms use to identify their customers. Branding. Regulatory Requirements to Establish Enterprises in Pakistan.

Unit 6. Establish New Venture Team and Management

Explain the concept called liabilities of newness. Describe a new-venture team and discuss the primary elements that form such a team. Identify professional advisers and explain their role with a new-venture team. Explain why a new-venture team might use consultants to obtain advice. Hierarchical Level. Duties and Responsibilities of Management Team. Education, Expertise, Skills and Experience.

Unit 7. Financial Literacy. Assessing a New Venture's Financial Strength and Viability

Basic concepts of income, savings and investments. Basic concepts of assets, liabilities and equity. Basic concepts of revenue and expenses. Sources of capital. Overview of cash-flows. Overview of banking products including Islamic modes of financing. Sources of funding for startups (angel financing, debt financing, equity financing etc.). Break-even analysis. Learn about the importance of understanding the financial management of an entrepreneurial firm. Main financial objectives of entrepreneurial firms. Process of financial management as used in entrepreneurial firms. Describe the different historical financial statements and their purpose. Taxation and financial reporting obligation. Entrepreneurial Strategies: Generating and exploiting new entries. Expansion and Management for future growth. three sources of personal financing available to entrepreneurs. Discuss the difference between equity funding and debt financing

Unit 8. Valuation of entrepreneurial ventures

Valuation of entrepreneurial ventures. The importance of business valuation. Underlying issues when acquiring a venture Due diligence. Analyzing the business. Establishing a firm's value

Recommended Books/ Reference Material

1. Barringer, B. R., & Ireland, R. D. (2016). Successfully launching new ventures.
2. Gupta, S. (2020). *Fundamentals of Entrepreneurship by Sanjay Gupta (eBook): SBPD Publications*. SBPD publications.
3. Hägg, G., & Kurczewska, A. (2022). *Entrepreneurship education: Scholarly progress and future challenges* (p. 101). Taylor & Francis.
4. Pruthi, S., & Mitra, J. (2023). *Global Entrepreneurship & Innovation*. SAGE.
5. Ries, E. (2022). The lean startup: how Today's entrepreneurs use continuous innovation to create radically successful businesses. E-book, Crown Business, New York.
6. Singh, K. K. (2023). *Women Entrepreneurship*. Guarav book center.

Civic and Community Engagement

Course Code: CCE-497

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with fundamental knowledge about civics, citizenship and community engagement. In this course the students will learn about the essential of civil society, government, civic responsibilities, inclusivity and effective ways to participate in shaping the society which will help them apply the theoretical knowledge to the real-world situation to make a positive impact on their communities.

Learning Outcomes

By the end of this course, student will be able to:

- Demonstrate fundamental understanding of civics, government, citizenship and civil society.
- Understand the concept of community and recognize the significance of community engagement for individuals and groups.
- Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

Course Outline

Unit 1. Civics and Citizenship

Concepts of civics, citizenship, and civic engagement. Foundations of modern society and citizenship. Types of citizenship: active, participatory, digital etc.

Unit 2. State, Government and Civil Society

Structure and function of government in Pakistan. The relationship between democracy and civil society. Right to vote and importance of political participation and representation.

Unit 3. Rights and Responsibilities

Overview of fundamental rights and liberties of citizens under constitution of Pakistan 1973. Civic responsibilities and duties. Ethical consideration in civic engagement (accountability, non-violence, peaceful dialogue, civility etc.).

Unit 4. Community Engagement

Concept, nature and characteristics of community. Community development and social cohesion. Approaches to effective community engagement. Case studies of successful community driven initiatives.

Unit 5. Advocacy and Activism

Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements.

Unit 6. Digital Citizenship and Technology

The use of digital platform for civic engagement. Cyber ethics and responsible use of social media. Digital divides and disparities (access, usage, socio-economic, geographic etc.) and their impact on citizenship.

Unit 7. Diversity, Inclusion and Social Justice

Understanding diversity in society (ethnic, cultural, economic, political etc.). Youth, women and minorities engagement in social development. Addressing social inequalities and injustices in Pakistan. Promoting inclusive citizenship and equal rights for social harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

Apart of the overall learning requirements, the course may have one or a combination of the following practical activities

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews or multimedia presentations that captured the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Student can organize a community event or workshop that addresses a specific issue or foster community interaction. This could be a health fair, environmental cleanup, cultural festival or educational workshop
3. **Service Learning:** Student can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time, and skills to address a particular community need, such as tutoring, mentoring or supporting vulnerable population.
4. **Cultural Exchange Activities:** Student can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances and presentations that promote cross cultural understanding.

Recommended Books/Reference Material

1. Džankić, J., & VINK, M. P. (2022). Citizenship & migration.
2. Kymlicka, W. and Norman, W. (2010). *Citizenship in Diverse Societies*. University Press, United Kingdom.
3. Mackert, J., & Turner, B. S. (2017). The Transformation of Citizenship, Volume 2. Boundaries of Inclusion and Exclusion.
4. Mattson, K. (2017). *Digital Citizenship in Action: Empowering Students to Engage in Online Communities*. : International Society for Technology in Education, United Kingdom.
5. McGraw-Hill Education, (2009). *Civics Today: Citizenship, Economics, & You*, Student Edition. United States.
6. Weinstock, D. (2017). Citizenship and Cultural Diversity. The Oxford Handbook of Citizenship.
7. Youniss, J. and Levine, J. (2009). *Engaging Young People in Civic Life*. Vanderbilt University Press, Ukraine.

13 List of Allied / Interdisciplinary Courses

Sr. No.	Course Code	Course Title	Pre-Requisite	Credit Hours
1.	STA-121	Introductory Statistics	Nil	3
2.	STA-XXX	Statistics and Probability	Nil	3
3.	PHY-104	Introduction to Mechanics	Nil	2
4.	PHY-104L	Introduction to Mechanics (Lab)	Nil	1
5.	MGT-105	Introduction to Digital Marketing	Nil	3
6.	MGT-101	Fundamentals of Accounting	Nil	3
7.	MGT-301	Business Finance	Nil	3
8.	CS-108	Introduction to Programming	NIL	2
9.	CS-108L	Introduction to Programming (Lab)	Nil	1
10.	CS-110	Advanced Programming	Nil	2
11.	CS-110L	Advanced Programming (Lab)	Nil	1
12.	CS-109	Introduction to Machine Learning	Nil	2
13.	CS-109L	Introduction to Machine Learning (Lab)	Nil	1
14.	CS-126	Digital Logic Design	Nil	2
15.	CS-126L	Digital Logic Design (Lab)	Nil	1
16.	CS-201	Software Engineering	Nil	3
17.	MGT-202	Financial Accounting-I	Nil	3
18.	MGT-304	Financial Accounting-II	Nil	3
19.	MGT-313	Cost and Management Accounting	Nil	3

14 Course Outlines for Allied / Interdisciplinary

Introductory Statistics

Course Code: STA-121

Credit Hours: 03

Pre-requisite: Nil

Objectives

To provide students basic understanding of statistical methods and its applications in various fields. This course focuses on descriptive statistics and its applications.

Learning Outcomes

- Student will understand the basic statistical concepts and able to explain measures of central tendency and dispersion.
- Students will be able to present the data using suitable graph, chart, and diagram.
- Students will be able to calculate and explain the difference between measure of absolute and relative dispersion.
- Students will be capable to apply regression and correlation analysis on data and interpret its results.

Course Outline

Unit 1. Introduction to Statistics and Presentation of data

Basic definitions, characteristics, limitations and uses of statistics. Types of data. Classification and tabulation of data. Frequency distribution. Stem and leaf display. Graphical presentation. Diagrams and graphs.

Unit 2. Measure of Central Tendency

Definitions and types of averages. Criteria of good average. Arithmetic mean and its properties (ungrouped & grouped data). Geometric mean (ungrouped & grouped data). Harmonic mean (ungrouped & grouped data). Mode (ungrouped & grouped data). Median and quantiles (ungrouped & grouped data)

Unit 3. Measures of Dispersion

Range, quartile deviation and their coefficients. Mean deviation and coefficient of mean deviation. Variance and standard deviation. Coefficients of variation. Trimmed and winsorized measures.

Unit 4. Measure of Symmetry and Skewness

Moments about arbitrary value and mean. Concept of symmetry and skewness. Moment ratios. Measures of skewness and kurtosis.

Unit 5. Regression and Correlation Analysis

Regression and its application. Residual plot. Simple Correlation, its application and properties. Rank correlation. Association.

Recommended Books/Reference Material

1. Chaudhry S.M. & Kamal. S. (2018). *Introduction to Statistical Theory Part I*. Ilmi Kitab Khana Lahore, Pakistan.
2. Hogg, R., McKean, J. & Craig, A. (2021). *Introduction to Mathematical Statistics*, (8th ed.). Pearson Education, Boston.
3. Illowsky, B., Dean, S. & Openstax. (2022). *Introductory Statistics*. Open Stax Textbooks.
4. Moore, D. S., McCabe, G.P. & Craig, B. A. (2021). *Introduction to the Practice of Statistics*, (10th ed.). WH Freeman, New York.
5. Walpole, R. E. (2002). *Introduction to Statistics*, (7th ed.). Macmillan publishing company, New York.

Statistics and Probability

BS-Statistics

Course Code: STA-

Credit Hours: 03

Pre-requisite: Nil

Objectives

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of other sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. Furthermore, the course focuses on basic principles of probability and probability distributions for discrete and continuous random variables.

Learning Outcomes

- Students will be capable to explain the random variables, discrete and continuous random variables, and their probability distributions.
- Students will gain understanding to apply the probability distribution on scientific studies and interpret the results of statistical analyses accurately and effectively.
- Student will understand the basic statistical concepts and able to calculate and explain measures of central tendency and dispersion.
- Students will be able to present the data using suitable graph, chart, and diagram.

Course Outline

Unit 1. Introduction to Statistics & Presentation of data

Introduction Statistics, important statistical terms, variable, data & data collection. Classification and tabulation of data. Frequency distribution, its construction and other related concepts. Graphical Presentation: Simple bar chart, Component & Multiple bar chart, Pie chart, Histogram, Frequency polygon and Ogive.

Unit 2. Measures of Central Tendency

Mean, Median & Mode for ungrouped and grouped data, quartiles, deciles and percentiles for ungrouped & grouped data.

Unit 3. Measures of Dispersion

Absolute and relative measures of dispersion for ungrouped and grouped data.

Moments about mean. Measures of skewness and kurtosis. Moment-ratios.

Unit 4. Probability & Probability Distributions

Introduction to probability theory, types of events. Functions of classical probability with real world problems. Numerical examples of probability. Concept of random variable, discrete and continuous random variables. Binomial probability distribution & its numerical examples

Unit 5. Discrete and Continuous Probability Distributions

Binomial probability distribution & its numerical examples. Hyper geometric probability distribution & its numerical examples. Poisson probability distribution & numerical examples related to it. Normal distribution, numerical examples with direct & inverse use of area table for standard normal distribution.

Recommended Books/Reference Material

1. Carlton, M.A. & Devore, J.L. (2020). *Probability with STEM Applications*. (3rd ed.). Wiley.
2. Chaudhry S.M. & Kamal. S. (2018). *Introduction to Statistical Theory Part 1*. Ilmi Kitab Khana Lahore, Pakistan.
3. Hogg, R., Mckean, J. & Craig, A. (2021). *Introduction to Mathematical Statistics*, (8th ed.). Pearson, Boston.
4. Mendenhall, W., Beaver, R. J. & Beaver, B. M. (2012). *Introduction to Probability and Statistics*. Cengage Learning.
5. Mood, A.M., Graybill, F.A. & Boes, D.C. (1974). *Introduction to the Theory of Statistics* (3rd ed.). McGraw Hill, New York.
6. Scheaffer, R. L., Mulekar, M. & McClave, J. T. (2010). *Probability and Statistics for Engineers*. Cengage Learning.
7. Walpole, R. E. (2002). *Introduction to Statistics* (7th ed.). Macmillan publishing company, New York.
8. Walpole, R.E., Myers, R.H. & Myers, S.L. (1998). *Probability and Statistics for Engineers and Scientist* (6th ed.). Prentice Hall, New York.
9. Weiss, N. A. & Hassett, M. J. (1999). *Introductory Statistics*. Boston: Addison-Wesley.

Introduction to Mechanics

Course Code: PHY-104

Credit Hours: 03

Pre-requisite: NIL

Objectives

Students will acquire understanding about the kinematics and dynamics of an object, their use in sample mechanical system with quantitative analysis. They will also learn and develop understanding about Newton's laws and its applications.

Learning Outcomes

By the end of this course, the students will be able to

- Understand the basic principles of statics and dynamics in mechanical systems.
- Apply the laws of motion to solve problems involving forces, energy, and momentum.
- Analyze mechanical systems and predict their behavior under different conditions.

Course Outline

Unit 1. Vector Analysis

Basic concept of units, vectors and scalars, Addition of vectors by graphical and component method. Multiplication of vectors, vectors in three dimensions and fundamental operations. Direction cosines, vector and scalar Triple products. Spherical Polar coordinates cylindrical coordinates. Concept of Gradient, Gradient of a scalar, Divergence and Curl of a vector, Physical significance of each type, Divergence Theorem, Stoke's Theorem.

Unit 2. Particle Dynamics

Newton's laws of motion and their applications, Equation of motion, Projectile motion, Drag force & motion of projectiles. Uniform circular motion, forces laws, tension & normal force, the dynamics of Uniform circular motion the conical pendulum, the Rotor, the banked curve). Collisions, linear Momentum, Impulse, Conservation of Momentum, Two body collisions, one dimensional collision in center of mass reference frame.

Unit 3. System of particles

Motion of a system of particles, two particle system, many particle systems, centers of mass of solid objects, Conservation of momentum in a system of Particles.

Unit 4. Work and Kinetic Energy

Work done by constant force, Work done by variable force, work done by spring force, The Work-energy Theorem, Inelastic collision.

Unit 5. Gravitation

Newton law of Universal gravitation, the two shell theorems, Gravitational potential energy, Escape speed, Motion of planets and Kepler's laws.

Unit 6. Rotational motion

Rotational quantities as vectors, rotation with constant angular acceleration, Relationship between linear and angular variables, Rotational kinetic energy, Torque, Rotational inertia,

and newton's second law, Perpendicular axis theorem, Parallel theorem, Moment of inertia of solid cylinder, uniform rod and hollow cylinder.

Unit 7. Angular Momentum

Angular momentum of a particle, Angular momentum of a system of particles, conservation of angular momentum, angular, spinning top.

Recommended books/reference material

1. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of Physics* (12th ed.). John Wiley.
2. Kleppner, D., & Kolenkow, R. (2013). *An Introduction to Mechanics*. Cambridge University Press.
3. Resnick, R., Halliday, D., & Krane, K. S. (2002). *Physics* (5th ed.). Wiley.
4. Young, H. D., & Freedman, R. A. (2019). *University Physics with Modern Physics* (15th ed.). Addison-Wesley.

Introduction to Mechanics (Lab)

Course Code: PHY-104L

Credit Hours: 01

Pre-requisite: NIL

Objectives

These experiments cover fundamental principles in mechanics and provide students with hands-on experience in conducting experiments, analyzing data, and drawing conclusions in the field of physics.

Learning Outcomes

- Practical approach and understanding of laws and forms of motion and their applications in daily life.
- Implementation and knowledge of work, energy and different systems of particles and center of mass concept and usage.
- Knowledge and understanding of rotational dynamics.
- To understand laws of gravitation and planetary motion and applications of Kepler's laws.

Course Outline

List of Experiments

1. Experimentally determine the acceleration due to gravity (g) by timing the free fall of an object from a known height using a photo-gate timer or a simple pendulum.
2. Investigate the relationship between the force applied to an object and its resulting acceleration using a dynamics cart on an inclined plane or a mass on a frictionless surface.
3. Explore the conservation of momentum by colliding two objects on an air track or a table with low-friction surfaces. Examine elastic and inelastic collisions.
4. Study SHM by analyzing the motion of a simple pendulum or a mass-spring system. Determine factors affecting the period and amplitude of oscillation.
5. Investigate the relationship between centripetal force, mass, and radius of rotation using a rotating platform or a conical pendulum.

6. Determine the coefficient of friction between different surfaces using an inclined plane and a variety of objects. Analyze static and kinetic friction.
7. Study the concept of work and energy conservation by lifting weights to various heights and calculating the work done and potential energy gained.
8. Analyze the trajectory of a projectile by launching objects at different angles and velocities, and calculate the range, maximum height, and time of flight.
9. Explore the principles of rotational motion using rotating wheels or disks. Investigate angular velocity, moment of inertia, and angular acceleration.
10. Experiment with objects in rotational equilibrium and determine the torque needed to maintain equilibrium. Use a meter stick or a balance beam.
11. Verify Hooke's Law by applying different forces to a spring and measuring the resulting elongation or compression.
12. Investigate how the period of a simple pendulum changes with different lengths and compare your results to theoretical predictions.
13. Study rolling motion by releasing objects down an incline and measuring their acceleration. Compare the results to theoretical predictions for pure rolling.
14. Determine the coefficient of restitution by dropping a ball onto a hard surface and measuring the rebound height.
15. Explore the conservation of angular momentum using a rotating chair and observe changes in rotational speed when the chair's arms are extended or brought closer.

Recommended Books/Reference Material

1. Loyd, D. H. (2008). *Physics Laboratory Manual*. Thomson Higher Education.
2. Smith, W. F. (2020). *Experimental Physics: Principles and Practice for the Laboratory*. Taylor and Francis.
3. Wilson, J. D., & Hernández-Hall, C. A. (2014). *Physics Laboratory Experiments*. Cengage Learning.

Introduction to Digital Marketing

Course Code: MGT-105

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to enhance the conceptual knowledge of marketing as applicable to decision making process with a focus on tactical marketing mix decisions. Further it will provide the student with a comprehensive framework to evaluate marketing decisions and to create successful marketing initiatives. The course, will therefore, provide an understanding of the principles of marketing in relation to the product and services including the planning process, organizing the marketing functions, implementing the marketing decisions keeping in mind the ethical, legal and societal consideration.

Learning Outcomes

By the end of this course, students will:

- Be able to understand the marketplace and the consumers.
- Be able to comprehend the elements in marketing mix and their application in marketing decisions.
- Be able to analyse the functions of marketing communication.

Course Outline

Unit 1. Introduction To Marketing

Marketing and the Society. Importance and scope of marketing. Definition of marketing. Nature and concept of marketing

Unit 2. Marketing Environments

The Marketing environment. Macro environment. Micro environment
Environmental scanning and monitoring. Marketing & strategy. Strategic planning.
Strategic marketing planning. Forecasting marketing demand

Unit 3. Marketing Decisions

Information required for marketing decisions. Reasons for obtaining information
Marketing research

Unit 4. Consumer Behavior

Information for purchase decisions. Consumer decision process. Influence of social
and psychological factors. Market implications

Unit 5. Market Segmentation and Targeting, Introduction To E-Business

Factors for Segmentation. Selecting the target market. Developing the positioning
and target market strategies. Different trends. Rules of doing e-business. E-business
application in the market

Unit 6. Products And Services

Definition of product and services. Classification of consumer goods. Classification
of business goods, Product development and life cycle. Product development
process and commercialization. Product life cycle stages and its implications

Unit 7. Pricing

Overview of pricing. Importance of pricing. Break even analysis. Factor effecting
pricing decisions. Price setting and relating strategies. Pricing objectives. Sale
based objectives. Profit based objectives. Status quo Pricing. Price strategy. Pricing
techniques and their applications, Cost based pricing, Cost plus pricing, Target
pricing, Floor pricing

Unit 8. Distribution & Promotion, Advertisement and publicity

Importance of distribution channels. Selecting a channel of distribution. Retail
functions in distribution. Recent trends in wholesaling and retailing. Importance

and types of promotion. Channels of communication. Objectives, budgeting and promotional mix. Legal environments of promotion. Scope of advertisement and publicity. Characteristic of advertisement and publicity. Development, planning and implementation of advertising plan. Evaluating the success and failure of promotional plan

Recommended Books/ Reference Material

1. Baines, P., Whitehouse, S., Antonetti, P., & Rosengren, S. (2021). *Fundamentals of Marketing 2e*. Oxford University Press, USA.
2. Jobber, D., & Ellis-Chadwick, F. (2021). Principles and practice of marketing (No. 7th). McGraw-Hill Higher Education
3. Kotler, P., & Armstrong, G. (2023). Principles of marketing. Pearson education.
4. Kotler, P., Kartajaya, H., & Setiawan, I. (2021). *Marketing 5.0: Technology for humanity*. John Wiley & Sons.
5. Morrison, A. M. (2022). *Hospitality and travel marketing*. Taylor & Francis

Fundamentals of Accounting

Course Code: MGT-101

Credit Hours: 03

Pre-requisite: Nil

Objectives

The primary aim of Financial Accounting is to provide students with an introduction to the process and function of financial reporting. Whilst a large proportion of the course is aimed at understanding accounting as a process, taking a preparer's perspective, we will also seek to develop an understanding of the importance of the role of accounting in today's society.

Learning Outcomes

By the end of this course, students will:

- Be able to understand accounting and financial reporting;
- Be able to comprehend complete accounting cycle
- Be able to Prepare financial issues and the role of Journal, Ledger and subsidiary books, Preparation of balance sheet, profit and loss account and cash flow statement.

Course Outline

Unit 1. Accounting: Information For Decision Making

Accounting Information: A Means to an End, Accounting Systems. Financial Accounting Information. Management Accounting Information. Integrity of Accounting Information. Careers in Accounting.

Unit 2. Basic Financial Statements

Introduction to Financial Statements. A Starting Point: Statement of Financial Position. Income Statement. Statement of Cash Flows, Relationships among Financial Statements. Financial Analysis and Decision Making. Forms of Business Organization. The Use of Financial Statements by External Parties.

Unit 3. The Accounting Cycle: Capturing Economic Events

The Accounting Cycle. The Ledger. The Use of Accounts, Debit and Credit Entries. The Journal, Recording Balance Sheet Transactions: An Illustration. Ledger Accounts after Posting. What Is Net Income? Dividends. Recording Income Statement Transactions: An Illustration. February's Ledger Balances. The Trial Balance

Unit 4. The Accounting Cycle: Accruals and Deferrals

The Need for Adjusting Entries. Types of Adjusting Entries. Adjusting Entries and Timing Differences. Characteristics of Adjusting Entries. Year-End at Overnight Auto Service. Converting Assets to Expenses. The Concept of Depreciation. Converting Liabilities to Revenue. Accruing Unpaid Expenses. Accruing Uncollected Revenue. Accruing Income Taxes Expense: The Final Adjusting Entry

Unit 5. The Accounting Cycle: Reporting Financial Results

Preparing financial statements. Relationships among the financial statements. Drafting the notes that accompany financial statements. What types of information must be disclosed? Closing the temporary accounts. Closing entries for revenue accounts. Closing entries for expense accounts. Closing the income summary account. Closing the dividends account. Summary of the closing process. After-closing trial balance. Financial analysis and decision making. Preparing financial statements covering different periods of time

Unit 6. Merchandising Activities

Merchandising Companies. The Operating Cycle of a Merchandising Company. Income Statement of a Merchandising Company. Accounting System Requirements for Merchandising Companies. Two Approaches Used in Accounting for Merchandise Inventories. Perpetual Inventory Systems. Periodic Inventory Systems. Comparison of Perpetual and Period Inventory Systems. Transactions Relating to Purchases/sales. Modifying an Accounting System. Special Journals Provide Speed and Efficiency

Recommended Books/ Reference Material

1. Bettner, M., Williams, J., Haka, S., & Carcello, J. (2023). Financial & Managerial Accounting. (Latest Edition)
2. Khan, (2021): Financial Accounting. Pakistan
3. Kimmel, P. D., Weygandt, J. J., & Kieso, D. E. (2020). *Financial accounting: tools for business decision-making*. John Wiley & Sons.

4. Narayanaswamy, R. (2022). *Financial accounting: a managerial perspective*. PHI Learning Pvt. Ltd..
5. Schroeder, R. G., Clark, M. W., & Cathey, J. M. (2022). *Financial accounting theory and analysis: text and cases*. John Wiley & Sons.

Business Finance

Course Code: MGT-301

Credit Hours: 03

Pre-requisite: Nil

Objectives

Business Finance course aims at imparting knowledge about the very basic concepts and tools of Business Finance. It emphasizes the importance of Business Finance skills to individuals and enterprises. It deals with the finance function in an organization, the role of the finance manager and the financial environment in which the firm operates. The financial environment covers the understanding of financial and capital markets along with the broad orientation of macro-economic factors affecting the business. The emphasis will remain on developing the skills for planning, appraising and evaluating the investment, financing and operating decisions.

Learning Outcomes

After studying this course, the student will be able to:

- Understand the basics of finance theory and its applications to corporate financial decisions.
- Do Analysis of financial statements.
- Comprehend tools and techniques of time value of money for investing decisions.

Course Outline

Unit 1. An Overview of Business Finance

Finance a quick look. Business finance and financial manager. Forms of business organization. Goals of business finance. Agency problem.

Unit 2. Understanding Financial Statements And Cash Flows

The balance sheets. The income statement. Taxes. Cash flow.

Unit 3. Analyzing The Financial Statements

Standardized financial statements. Ratio analysis. The Du-Pont identity. Internal and sustainable growth. Using financial statement information.

Unit 4. Time Value of Money

The role and perspectives of the TVM concept. Future values / Present values. The relationship between future and present values. Annuities. Present values of cash

flows under high compounding frequency. Future values of cash flows under high compounding frequency. Impact of higher compounding frequency. Inflation and the Time Value of Money.

Unit 5. Bond and Their Valuation, Risk and Return

Definition, types and features of bonds. Valuation of bonds (the basic process). Basic relationships in bond valuation. Bondholder's expected rate of return. Risks associated with bond returns. Expected returns and risk defined. Calculating expected return. Calculating risk (Variance and Standard deviation). Portfolio expected returns. Portfolio variance and standard deviation. Systematic and unsystematic risk. Diversification and portfolio risk

Unit 6. Stocks and Their Valuation

Shares and their basic features. Benefits from a share investment. Price of ordinary shares. Behaviour of expected dividend growth and share price. Price of shares based on earnings. Expected rate of return. Preferred shares and their characteristics. Price of preferred shares and the expected rate of return. Valuing the entire business

Unit 7. Net present value and other investment Criteria, The Cost of Capital

Net present value. The payback rule. The average accounting return. The internal rate of return. The profitability index. The practice of capital budgeting. The cost of capital concepts. Individual and weighted average costs of capital. Costs of capital and valuation. Capital structure. Capital structure decision (No taxes or other capital market imperfections). Taxation and capital structure decision. Debt equity ratio, cost of capital and the value of the firm (The MM Propositions). Optimal capital structure. Costs of financial distress and bankruptcy. The static trade-off theory. The pecking order theory. Personal taxes. Evidence on capital structure determinants

Unit 8. Introduction to Islamic Finance.

Mudarba, Musharqa, Murabah, Ijara. Comparison with the conventional financial system.

Recommended Books/ Reference Material

1. Brigham, E. F., & Houston, J. F. (2021). Fundamentals of Financial Management. Cengage Learning. (Latest edition)
2. Gitman, L. J., & Madura, J. (2022). Introduction to Finance. Addison Wesley. Ross, Westerfield, Jordan: Corporate Finance Essentials. (Latest edition)
3. Harvey, C. R., Ramachandran, A., & Santoro, J. (2021). *DeFi and the Future of Finance*. John Wiley & Sons.
4. Moffett, Michael H., Arthur I. Stonehill, and David K. Eiteman (2021). *Fundamentals of multinational finance*. Pearson

5. Palepu, K. G., Healy, P. M., Wright, S., Bradbury, M., & Coulton, J. (2023). *Business analysis and valuation: Using financial statements*. Cengage AU.

Introduction to Programming

BS Mathematics

Course Code: CS-108

Course Type: Interdisciplinary

Credit Hours: 2

Pre-requisite: Nil

Objectives

- Understand basic programming constructs and logic formulation.
- Write and trace simple C programs using decision-making and loops.
- Use functions and arrays for structured problem solving.
- Perform basic file input/output operations.

Learning Outcomes

- Describe fundamental programming concepts (variables, loops, and conditionals).
- Develop and test structured programs using C language.
- Solve mathematical and logical problems through basic programs.

Course Outline

Unit 1: Introduction to Programming Concepts and C Language

Algorithms and flowcharts help plan programs visually. In C, variables, data types, and constants store data, while scanf and printf handle input/output. Operators perform calculations, and precedence rules ensure correct expression evaluation.

Unit 2: Control Structures

Conditional statements like if, if-else, and switch control program flow based on conditions. Looping structures (while, for, do-while) repeat tasks, often used in simple math examples like calculating sums or factorials.

Unit 3: Functions

Functions help organize code by defining reusable blocks. Variable scope determines where a variable can be accessed. Call by value passes a copy of data, while call by reference passes the actual data. Standard library functions perform common tasks like math and string handling.

Unit 4: Arrays

Arrays store multiple values of the same type. One-dimensional and two-dimensional arrays handle linear and tabular data, useful in basic math computations like sums, averages, and matrix operations.

Unit 5: Basic File Handling

Text file handling allows reading and writing data to files. File pointers manage file access in C. Simple programs use them to store and retrieve data for basic input/output operations.

Recommended Books

1. Hanly, J. R., & Koffman, E. B. (2012). *Problem Solving and Program Design in C* (7th ed.). Pearson.
2. Gaddis, T. (2017). *Starting Out with C++ from Control Structures to Objects* (9th ed.). Pearson.
3. Kernighan, B. W., & Ritchie, D. M. (1988). *The C Programming Language* (2nd ed.). Pearson.

Introduction to Programming (Lab)

BS Mathematics**Course Code:** CS-108L**Course Type:** Interdisciplinary**Credit Hours:** 1**Pre-requisite:** Nil**Objectives**

- Practice implementation of fundamental programming concepts.
- Build small programs using decision-making, loops, and arrays.
- Handle files through basic input/output programs.

Learning Outcomes

- Write and execute simple C programs.
- Apply structured programming techniques to real-world problems.
- Perform file operations using C.

Course Outline**Unit 1: Basic C Programs**

Simple I/O programs use scanf and printf for user interaction. Data types and arithmetic operations handle numerical tasks, while expressions follow operator precedence for correct results.

Unit 2: Control Structures in Practice

Programs use conditional (if, switch) and looping (for, while) statements for control flow. These help solve problems by repeating tasks and making decisions based on conditions.

Unit 3: Functions

User-defined functions organize code into reusable parts. Parameter passing can be by value (copy) or by reference (direct access). Built-in functions simplify tasks like math, strings, and I/O in programs.

Unit 4: Arrays

1D and 2D arrays store and manage data efficiently. Programs use them to handle lists of numbers, perform searching, and calculate sums or other operations easily.

Unit 5: File Handling Basics

Text files can be created and read to store data permanently. Programs can append new content and display file data, demonstrating how information persists between runs.

Recommended Books

1. Bejarano, A., Dickey, E., & Setsma, R. (2025, February). Implementing the AI-Lab Framework: Enhancing Introductory Programming Education for CS Majors. In *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 2* (pp. 1383-1384).
2. Tufino, E., Oss, S., & Alemani, M. (2025, February). Using Jupyter Notebooks to foster computational skills and professional practice in an introductory physics lab course. In *Journal of Physics: Conference Series* (Vol. 2950, No. 1, p. 012022). IOP Publishing.
3. using Python, B. F. S. Department of Computer Applications BCA-Semester II Minor Artificial Intelligence LAB Credits: 1 Lab: 2 Hours Tutorials:-Max Marks: 50 External: 50 Marks Internal. *BACHELOR OF COMPUTER APPLICATIONS Under CBCS*, 11.

Introduction to Machine Learning

Course Code: CS-109

Credit Hours: 1

Course Type: Interdisciplinary

Pre-requisite: None

Objectives

- Introduce foundational machine learning concepts to mathematics students.
- Explore the role of basic linear algebra and statistics in ML.

Learning Outcomes

- Understand supervised and unsupervised learning basics.
- Use Python libraries to run ML models on small datasets.
- Evaluate basic model performance.

Course Outline

Unit 1: Overview of AI and ML

AI, ML, and Deep Learning are technologies for building intelligent systems. Python libraries like NumPy, Matplotlib, Pandas, and scikit-learn are key tools for machine learning.

Unit 2: Mathematical Tools

Vectors and matrices organize data; gradients show change. Gradient descent optimizes by minimizing errors step-by-step.

Unit 3: Supervised Learning

Linear and logistic regression model data relationships. Decision trees and random forests are simple, powerful tools for classification and prediction.

Unit 4: Model Evaluation & Applications

Accuracy shows performance; confusion matrix details results. Overfitting is learning noise. Neural networks mimic the brain to learn data.

Recommended Books

1. Deisenroth, M.P. et al. (2020). *Mathematics for Machine Learning*. Cambridge University Press.
2. Chollet, F. (2021). *Deep Learning with Python*. Manning.
3. Aggarwal, C.C. (2023). *Neural Networks and Deep Learning*. Springer.

Introduction to Machine Learning (Lab)

Credit Hours: 1

Course Type: Interdisciplinary Lab

Lab Outline

Unit 1: Python Essentials for ML

NumPy, Pandas, plotting with Matplotlib

Unit 2: Linear Regression in Python

Fit and plot simple models

Unit 3: Classification with Logistic Regression & Decision Trees

Use scikit-learn models and evaluate performance

Unit 4: Basic Neural Network using Keras or sklearn

One hidden layer, training with small dataset

Recommended Books/Reference Material

1. Aggarwal, C.C., *Neural Networks and Deep Learning*, Springer, 2023.
2. Chollet, F., *Deep Learning with Python*, Manning Publications, 2021.
3. Deisenroth, M. P., *Mathematics for Machine Learning*, Cambridge University Press, 2020.
4. Liu, P. and Li, H.-X., *Fuzzy Neural Network Theory and Application*, World Sci. Pub. Com., 2004.
5. Russell, S., and Norvig, P., *Artificial Intelligence: A Modern Approach*, Pearson, 2020.

Advanced Programming

Program: BS Mathematics

Course Code: CS-110

Credit Hours: 2

Course Type: Interdisciplinary

Pre-requisite: None

Objectives

This course equips students with advanced programming tools commonly used in mathematics, science, and engineering. It focuses on solving mathematical problems using **MATLAB** and **Mathematica**, and typesetting technical documents using **LaTeX**.

Learning Outcomes

- Write and debug MATLAB and Mathematica programs for mathematical and scientific problem-solving.
- Perform symbolic and numerical computations in calculus, algebra, and matrix operations.
- Typeset mathematical documents and presentations professionally using LaTeX and Beamer.
- Prepare academic reports, assignments, and presentations with well-structured formatting and citations.

Course Outline

Unit 1. MATLAB Fundamentals

MATLAB's environment and syntax support working with variables, vectors, and matrices, plus built-in functions for calculus and linear algebra, along with visualization tools.

Unit 2. Programming Constructs in MATLAB

Script and function files use control structures like loops and conditionals, support user-defined functions, and include basic debugging and error handling features.

Unit 3. Symbolic Computation in Mathematica

Mathematica offers a symbolic algebra environment for simplifying, solving equations, computing derivatives and integrals, and creating 2D/3D plots.

Unit 4. Introduction to LaTeX

LaTeX provides a structured system for document classes, mathematical typesetting, symbols, and formatting tables, lists, figures, and equations.

Unit 5. Document Preparation and Presentations in LaTeX

LaTeX supports writing academic documents, managing references (BibTeX), creating presentations with Beamer, and using essential packages.

Recommended Books

1. Herniter, M.E. (2000). *Programming in MATLAB*. Cengage Learning.
2. Grätzer, G. (2007). *More Math into LaTeX*. Springer.
3. Muresan, M. (2017). *Introduction to Mathematica with Applications*. Springer.

Advanced Programming (Lab)

Credit Hours: 1

Course Type: Interdisciplinary Lab

Course Objective

- Apply programming techniques in **MATLAB** and **Mathematica** to solve algebraic and calculus problems.
- Practice creating professional documents and academic presentations using **LaTeX** and **Beamer**.
- Reinforce theoretical understanding through practical assignments and mini-projects.

Learning Outcomes

- Implement MATLAB programs involving vectors, matrices, functions, and plots.
- Use Mathematica for symbolic computation, equation solving, and visual representation of mathematical concepts.
- Create technical documents with complex mathematical expressions using LaTeX.
- Prepare structured academic reports and Beamer presentations using LaTeX.
- Collaborate and debug code in scientific computing environments.

Course Outline

Unit 1. Hands-on with MATLAB

Matrix and vector operations, 2D/3D plotting, solving linear systems, and symbolic derivatives and integrals are covered.

Unit 2. MATLAB Programming Practice

Writing and testing scripts and functions to solve real-world math problems using MATLAB algorithms.

Unit 3. Mathematica Applications

Interactive notebooks simplify algebra, solve calculus problems, and support visualization through plots and graphs.

Unit 4. LaTeX Practice

LaTeX projects involve writing math expressions, inserting figures, and generating tables of contents, references, and cross-references.

Unit 5. Report and Beamer Presentation

LaTeX enables creating academic reports and professional Beamer slides with overlays, blocks, and graphics for clear presentations.

Recommended Books/Reference Material

1. Herniter, M.E., *Programming in MATLAB*, Cengage Learning, 1st edition, 2000.
2. Hunt, B.R., Lipsman, R. L. and Rosenberg, J. M., *A Guide to MATLAB: For Beginners and Experienced Users 2nd Edition*, Cambridge University Press, 2nd edition, 2006.
3. Goossens, M., Mittelbach, F. and Rahtz, S. et al., *The LATEX Graphics Companion*, Addison Wesley, 2nd edition, 2008.
4. Grätzer, G., *More Math into LATEX*, Springer, 4th edition, 2007.
5. Muresan, M., *Introduction to Mathematica with Applications*, Springer Cham, 2017.

Digital Logic Design

BS-Computer Science

Course Code: CS-126

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course will provide an introduction to the fundamental concepts and techniques underlying the construction of digital systems. The course covers design of digital systems using standard, small, and medium scale integrated circuits. The main emphasis is on the theoretical concepts and systematic synthesis techniques that can be applied to the design of practical digital systems.

Learning Outcomes

- **Discuss** knowledge related to the concepts, tools and techniques for the design of digital electronic circuits (**C2 Understand**).
- **Demonstrate** the skills to design and analyze both combinational and sequential circuits using a variety of techniques (**C3 Apply**).
- **Apply** the acquired knowledge to simulate and implement small-scale digital circuits (**C3 Apply**).
- **Understand** the relationship between abstract logic characterizations and practical electrical implementations (**C2 Understand**).

Course Outline

Unit 1. Characteristics of Object-Oriented Languages, Structures & Functions

Introduction, Digital Systems and Information, Digital World, Analog Vs Digital, Number Systems; Base 2, Base 8, Base 16 , Binary Conversion Between Different Bases, Two's Complement, Binary Arithmetic Codes.

Unit 2. Logic Gates, K-Map

Combinational Logic Circuits, Gates (AND, OR, XOR etc), Combinational Logic Circuits, Boolean Algebra, Duality Principle, Combinational Logic, Standard

Forms., SOP and POS Forms , Min term, Max term, Canonical SOP, Canonical POS, Multiple Level Circuit Optimization, K-MAP, K-MAP Manipulation, Three Four Variable MAP , NAND NOR Gate Implementation, XOR Gate Implementation, Odd Function.

Unit 3. Combinational Circuits

Combinational Logic Design Using Building Blocks: Multiplexers, DE multiplexers, Decoders, Encoders, Arithmetic Functions: Adders-Sub tractors Arithmetic Functions (continued): Binary Multiplication, Contraction, Incrementing, and Decrementing.

Unit 4. Sequential Circuits

Basic Latches, S-R Latch, and Master –Slave Flip-Flops, Edge Triggered Flip-Flops, Sequential Circuits: Flip-Flops, D FFs, and Sequential Circuits: JK and T Flip Flops, Finite State Machines: Analysis.

Unit 5. Finite State Machines

Finite State Machines: State Table, Design, State Diagram, Applications, Diagram Model, Building Blocks, Programmable Implementation of Functions: PLA, PAL, ROM, Presentation and demonstrations of course project, Revision /Future perspective of the Course.

Recommended Books/Reference Material

1. Brown, S., & Vranesic, Z. (2008). EBOOK: Fundamentals of Digital Logic. McGraw Hill.
2. Floyd, T. L. (2009). Instructor's Resource Manual to Accompany Digital Fundamentals Tenth Edition. Pearson Prentice Hall.
3. Floyd, T. L. (2015). Digital Fundamentals, by Pearson. Pearson Education India.
4. LaMeres, B. J. (2023). Introduction to logic circuits & logic design with VHDL. Springer Nature.

5. Mano, M. M. (2017). Digital logic and computer design. Pearson Education India.
6. Roth Jr, C. H., Kinney, L. L., & John, E. B. (2020). Fundamentals of logic design. Cengage Learning.
7. Tocci, R. J. (1991). Digital systems: principles and applications. Pearson Education India.

Digital Logic Design LAB

BS-Computer Science

Course Code: CS-126L

Credit Hours: 01

Pre-requisite: Nil

Objectives

This course will describe and identify fundamental concepts of digital logic design including basic and universal gates, number systems, and binary coded systems, basic components of combinational and sequential circuits. It will transform the acquired knowledge to apply techniques related to the design and analysis of digital electronic circuits including Boolean algebra and multi-variable Karnaugh map methods. It will also analyze small-scale combinational and sequential digital circuits, design small-scale combinational and synchronous sequential digital circuit using Boolean algebra and K-maps.

Learning Outcomes

- **Discuss** knowledge related to the concepts, tools and techniques for the design of digital electronic circuits (**C2 Understand**).
- **Demonstrate** the skills to design and analyze both combinational and sequential circuits using a variety of techniques (**P3 Precision**).
- **Perform** the acquired knowledge to simulate and implement small-scale digital circuits (**P2 Manipulation**).
- **Understand** the relationship between abstract logic characterizations and practical electrical implementations (**C2 Understand**).

Course Outline

Unit 1. Introduction to Gates

Familiarization and verification of basic logic gates using ICs.

Unit 2. Verification of Basic Identities of Boolean Algebra

Verification of basic identities of Boolean algebra: Identity Law, Null (or Dominance) Law, Idempotent Law, Inverse Law, Double Complement Law, Associative Property, Distributive Property, etc.

Unit 3. Introduction to Combinational Circuit Modeling

Introduction to Combinational Circuit Modeling & Implementation of basic and universal gates.

Unit 4. Implementation of Half Adder and Full Adder

Implementation and Verification of half adder and full adder using basic gates and using universal gates. Implementation and verification of half adder. Implementation and verification of Full adder.

Unit 5. Implementation of BCD

Implementation of BCD to seven segment converter. Implementation of BCD to excess-3 code conversion. Implementation and verification of 4 x 1 multiplexer and 1 x 4 DE multiplexer circuits. RS flip-flop and D flip-flop using NAND gates.

Recommended Books/Reference Material

1. Brown, S., & Vranesic, Z. (2008). EBOOK: Fundamentals of Digital Logic. McGraw Hill.
2. Floyd, T. L. (2009). Instructor's Resource Manual to Accompany Digital Fundamentals Tenth Edition. Pearson Prentice Hall.
3. Floyd, T. L. (2015). Digital Fundamentals, by Pearson. Pearson Education India.
4. LaMeres, B. J. (2023). Introduction to logic circuits & logic design with VHDL. Springer Nature.

5. Mano, M. M. (2017). Digital logic and computer design. Pearson Education India.
6. Roth Jr, C. H., Kinney, L. L., & John, E. B. (2020). Fundamentals of logic design. Cengage Learning.
7. Tocci, R. J. (1991). Digital systems: principles and applications. Pearson Education India.

Software Engineering

Course Code: CS-201

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course aims to develop the students' knowledge of basic software terminologies, software life cycle activities, software process models and information systems. The students will also be familiarized with the UML to model software development.

Learning Outcomes

- **Describe** various software engineering processes and activates (**C2 Understand**).
- **Apply** the system modeling techniques to model a medium size software system (**C3 Apply**).
- **Apply** software quality assurance and testing principles to medium size software systems (**C3 Apply**).
- **Discuss** key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis (**C2 Understand**).

Course Outline

Unit 1. Introduction

The Scope of Software Engineering, Definition and Introduction to software engineering. History of SE, The Software: Software characteristics, Types of

software, difference between S/W engineering and CS and System Engineering, Ethical responsibilities, Software Processes, CMM and its level.

Unit 2. Process Models

A layered technology, S/W Processes Models , Reuse Oriented Software Engineering .Software Process Activities, Software Specification, Software Design and Implementation .Software Validation, Software Evolution. Coping with change. Software Requirement, Functional and nonfunctional requirement, Requirements Specification, Requirement elicitation and analysis, Requirement Evolution.

Unit 3. Introduction to UML

Software Modeling, UML Notations, Use case Diagram, Class Diagram, Activity Diagram, State machine diagram.

Unit 4. Application Architectures

Architectural Design, Architectural Views, And Architectural Patterns: Layered Systems, Repository Systems, Client Server System, And Application Architectures: Transaction Processing Systems, Information Systems, Language Processing Systems, Software Design, and Object Oriented Design, Design Patterns.

Unit 5. Testing & Management

Project Management Concepts, Software Testing, Development Testing: Unit Testing, Component Testing, System Testing, Test Driven Development, Release Testing: Cyclomatic Complexity, Software Configuration Management, Risk Management.

Recommended Books/Reference Material

1. Foster, E., & Towle Jr, B. (2021). Software engineering: a methodical approach. Auerbach Publications.

2. Pressman, R. S. (2005). Software engineering: a practitioner's approach. Palgrave macmillan.
3. Pressman, R. S., & Bruce R. Maxim, D. (2014). Software Engineering: A Practitioner's Approach. ISBN: 9780078022128.
4. Sommerville, I. (2015). Software engineering, 10th Edition. Pearson. ISBN: 9780133943030.
5. Tsui, F., Karam, O., & Bernal, B. (2022). Essentials of software engineering. Jones & Bartlett Learning.

Financial Accounting-I

BBA-Business Administration

Course Code: MGT-202

Credit Hours: 03

Pre-requisite: Nil

Objectives

The primary aim of Financial Accounting is to provide students with an introduction to the process and function of financial reporting. Whilst a large proportion of the course is aimed at understanding accounting as a process, taking a preparer's perspective, we will also seek to develop an understanding of the importance of the role of accounting in today's society.

Learning Outcomes

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

- Understand the language of accounting, financial reporting and accounting cycle.
- Comprehend and prepare the Journal, Ledger and subsidiary books.
- Preparation of balance sheet, profit and loss account and cash flow statement.

Course Outline

Unit 1. Accounting: Information For Decision Making

Accounting Information: A Means to an End, Accounting Systems. Financial Accounting Information. Management Accounting Information. Integrity of Accounting Information. Careers in Accounting.

Unit 2. Basic Financial Statements

Introduction to Financial Statements. A Starting Point: Statement of Financial Position. Income Statement. Statement of Cash Flows, Relationships among Financial Statements. Financial Analysis and

Decision Making. Forms of Business Organization. The Use of Financial Statements by External Parties.

Unit 3. The Accounting Cycle: Capturing Economic Events

The Accounting Cycle. The Ledger. The Use of Accounts, Debit and Credit Entries. The Journal, Recording Balance Sheet Transactions: An Illustration. Ledger Accounts after Posting. What Is Net Income? Dividends. Recording Income Statement Transactions: An Illustration. February's Ledger Balances. The Trial Balance

Unit 4. The Accounting Cycle: Accruals and Deferrals

The Need for Adjusting Entries. Types of Adjusting Entries. Adjusting Entries and Timing Differences. Characteristics of Adjusting Entries. Year-End at Overnight Auto Service. Converting Assets to Expenses. The Concept of Depreciation. Converting Liabilities to Revenue. Accruing Unpaid Expenses. Accruing Uncollected Revenue. Accruing Income Taxes Expense: The Final Adjusting Entry

Unit 5. The Accounting Cycle: Reporting Financial Results

Preparing financial statements. Relationships among the financial statements Drafting the notes that accompany financial statements. What types of information must be disclosed? Closing the temporary accounts. Closing entries for revenue accounts. Closing entries for expense accounts. Closing the income summary account. Closing the dividends account. Summary of the closing process. After-closing trial balance. Financial analysis and decision making. Preparing financial statements covering different periods of time

Unit 6. Merchandising Activities

Merchandising Companies. The Operating Cycle of a Merchandising Company Income Statement of a Merchandising Company. Accounting System Requirements for Merchandising Companies. Two Approaches Used in Accounting for Merchandise Inventories. Perpetual Inventory Systems. Periodic Inventory Systems. Comparison of Perpetual and Period Inventory Systems. Transactions Relating to Purchases/sales. Modifying an Accounting System. Special Journals Provide Speed and Efficiency

Recommended Books/ Reference Material

6. Bettner, M., Williams, J., Haka, S., & Carcello, J. (2023). Financial & Managerial Accounting. (Latest Edition)
7. Khan, (2021): Financial Accounting. Pakistan
8. Kimmel, P. D., Weygandt, J. J., & Kieso, D. E. (2020). *Financial accounting: tools for business decision-making*. John Wiley & Sons.
9. Narayanaswamy, R. (2022). *Financial accounting: a managerial perspective*. PHI Learning Pvt. Ltd.

10. Schroeder, R. G., Clark, M. W., & Cathey, J. M. (2022). *Financial accounting theory and analysis: text and cases*. John Wiley & Sons.

Financial Accounting-II

BBA-Business Administration

Course Code: MGT-304

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is built upon the Financial Accounting Course in the sense that it provides advanced treatment of basic techniques learned in the first course of Financial Accounting. It mainly focuses upon the company accounts and their understanding in the context of the IAS and companies' ordinance 1984.

Learning Outcomes

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

- Understand the formation of companies and important financial statements (balance sheet, income statement/profit and loss account, cash flow statement, statement of owner equity) of Public Limited companies.
- Comprehend about company annual report and notes to the accounts.
- Apply accounting for partnership and non-profit organizations.

Course Outline

Unit 1. Financial Assets

How Much Cash Should a Business Have? The Valuation of Financial Assets. Reconciling the Bank Statement. Short-Term Investments. Accounting for Marketable Securities. Accounts Receivable. Notes Receivable and Interest Revenue.

Unit 2. Inventory & Cost of Goods Sold

Inventory Defined. The Flow of Inventory Costs. Taking a Physical Inventory.

Unit 3. Plant And Intangible Assets

Plant Assets as a "Stream of Future Services". Major Categories of Plant Assets. Accountable Events in the Lives of Plant Assets. Acquisitions of Plant Assets. Depreciation methods. Disposal of Plant and Equipment. Intangible Assets. Natural Resources. Plant Transactions and the Statement of Cash Flows.

Unit 4. Liabilities

The Nature of Liabilities. Current Liabilities. Long-Term Liabilities. Estimated Liabilities, Loss Contingencies, and Commitments. Evaluating the Safety of Creditors' Claims. Special Types of Liabilities.

Unit 5. Stockholders' Equity: Paid-In Capital

Corporations. Formation of a Corporation. Paid-In Capital of a Corporation_Market Value. Treasury Stock.

Unit 6. Income And Changes in Retained Earnings

Reporting the Results of Operations. Other Transactions Affecting Retained Earnings.

Unit 7. Statement of Cash Flows

Statement of Cash Flows. Preparing a Statement of Cash Flows. Managing Cash Flows.

Unit 8. Financial Statement Analysis

Financial Statements Are Designed for Analysis. Tools of Analysis. Measures of Liquidity and Credit Risk. Measures of Profitability. Comprehensive Illustration: Seaclyff Company.

Recommended Books/ Reference Material

1. Bettner, M., Williams, J., Haka, S., &Carcello, J. (2023). Financial & Managerial Accounting. (Latest Edition)
2. Khan, (2021): Financial Accounting. Pakistan
3. Kimmel, P. D., Weygandt, J. J., & Kieso, D. E. (2020). *Financial accounting: tools for business decision-making*. John Wiley & Sons.
4. Schroeder, R. G., Clark, M. W., & Cathey, J. M. (2022). *Financial accounting theory and analysis: text and cases*. John Wiley & Sons.
5. Warren, C. S., Jones, J. P., & Tayler, W. B. (2020). *Financial and managerial accounting*. Cengage Learning, Inc.

Cost and Management Accounting

BBA-Business Administration

Course Code: MGT-313

Credit Hours: 03

Pre-requisite: Nil

Objectives

The Course deals with examining Cost Accounting as a tool for providing information for manufacturing, internal reporting, external reporting as well as for managerial decision making. The broad course objectives are to help students to

understand the central concepts of Cost Accounting, the methods of conducting data analysis preparation of reports for managerial decision making.

Learning Outcomes

After studying this course, the student will be able to:

- Understand the importance of Cost Accounting as a first step in the Manufacturing process.
- Analyse the Cost Accounting and explain its purpose within an organization.
- Comprehend the Cost data for the decision making of the higher management.

Course Outline

Unit 1. Concept And Scope of Cost Accounting

Definition and concept of cost. Cost object, Cost elements. Definition, concept and scope of cost accounting. Objectives of cost accounting. Cost Accounting Vs Financial Accounting. Use of cost data. Chart of accounts and coding for costing.

Unit 2. Cost Classification and Flow

Product and period cost, Direct and indirect cost, Differential cost and revenue, Opportunity and sunk cost, Fixed, variable and mixed cost, Statement of cost of goods manufactured, Statement of cost of goods sold.

Unit 3. Material Costing, Planning and Control

Procedure for material procurement and use. Material costing methods Costing Procedure for spoiled, scrap and defective work. Planning materials requirement (EOQ, Inventory levels and reserve stocks). Materials control (Principles and Methods).

Unit 4. Labour Costing, Control and Accounting

Productivity and efficiency of Labour.

Unit 5. Remuneration Methods

Straight piece rate, Differential piece rate, Incentive wage plans, Learning curve theory. Organisation for Labour cost accounting and control. Accounting for labor related costs. Overtime, Bonus payments, Vacation pay, Guaranteed annual wage plans, Apprenticeship and training programs, Pension. Labor related deductions.

Unit 6. Factory Overhead Costing and Control

Nature of factory overhead. Procedure of factory overheads. Allocation, apportionment, reapportionment and absorption. Repeated

distribution and algebraic method for reciprocal, service department costs. Calculation and use of predetermined factory overhead rate. Applied and actual FOH, Under /over applied FOH.

15 List of Minor Courses

BS Mathematics with Computer Science/Artificial Intelligence

Sr#	Course Code	Course Title	Pre- Reqs	Cr Hr.
1.	CS-122	Programming Fundamentals		3
2.	CS-122L	Programming Fundamentals (Lab)		1
3.	CS-111	Fundamentals of Object Oriented Programming	Programming Fundamentals	2
4.	CS-111L	Fundamentals of Object Oriented Programming (Lab)	Programming Fundamentals	1
5.	CS-206	Artificial Intelligence		2
6.	CS-206L	Artificial Intelligence (Lab)		1
7.	CS-308	Game Development	Nil	3
8.	CS-315	Digital Image Processing	Nil	3
9.	CS-317	Theory of Automata	Nil	3
10.	CS-322	HCI and Computer Graphics	Nil	2
11.	CS-322L	HCI and Computer Graphics (Lab)	Nil	1
12.	CS-404	Data Science	Nil	3
13.	CS-406	Cloud Computing	Nil	3
14.	CS-408	Mobile Application Development	Nil	2
15.	CS-408L	Mobile Application Development (Lab)	Nil	1
16.	CS-407	Web Engineering	Nil	2
17.	CS-407L	Web Engineering (Lab)	Nil	1
18.	CS-113	Introduction to Data Science	Nil	2
19.	CS-113L	Introduction to Data Science (Lab)	Nil	1

BS Mathematics with Finance

Sr. No.	Course Code	Course Title	Pre-Requisite	Credit Hours
1.	FIN 411	International Finance		3
2.	FIN 412	Financial Statement Analysis		3
3.	FIN 413	Corporate Finance		3
4.	FIN 414	Security Analysis and Portfolio Management		3
5.	FIN 415	Financial Risk Management		3
6.	FIN 416	Islamic Banking		3
7.	FIN 417	Financial Analytics		3
8.	FIN 418	Financial Reporting and Analysis		3

16 Course Outlines for Minor Courses

Course Outlines BS Mathematics with Computer Science

Programming Fundamentals

Course Code: CS-122

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of course is to introduce a disciplined approach to Problem solving methods and algorithm development. The aim is to teach the syntax and vocabulary of a modern programming language like C++. The significant philosophies and logical programming, including models or I/O, processing, and all related terminology will be taught. Simple programs will be constructed, using a number of different logical, calculation and algorithm.

Learning Outcomes

- **Understand** fundamental concepts of structured programming along with problem solving techniques and analytical thinking **(C2 Understand)**.
- **Analyze** problem requirements to recognize what type of data and processes are involved in solution **(C4 Analyze)**.
- **Apply** basic concepts to alter and expand short programs and algorithms. Writing pseudo-codes and simple program development using standard control structures and functions **(C3 Apply)**.
- **Design** module-based approach to gratify those requirements, and organize program code for implementation **(C6 Create)**.

Course Outline

Unit 1. Introduction, Declarations, Control Structures

Analyzing, implementation, testing and debugging, Object oriented programming languages, What is C, Getting Started with C, Computer Program Engineering, Decision Control structure (if statement, Multiple Statements within if, if-else statement, Nested if-else's), logical operators Hierarchy and conditional operators.

Unit 2. Loops, Statements, Functions

Loops structure (while, do while, for loop), break statement, continue statement, goto statement, case control structure, Decisions using switch, Function (prototype, declaration, calling, function body), User & system defined functions, Why use functions, Parameters, arguments, Passing values between functions, Scope rule of functions, Advanced features of functions, Call by value and call by reference, Recursion , Fibonacci series, Recursion vs. iteration.

Unit 3. Arrays & Pointers

What are arrays, Array initialization, Bounds checking, Passing array elements to functions, Passing an entire array to a function, More the one dimension, Initializing A 2-Dimensional array, Memory map of 2-Demensional array, Three Dimensional arrays, Puppeting on string, What are strings, More about string., Pointers overview, Return data from function, Pointer and array, Pointers and strings, Double indirection ,Pointers to pointers , Pointer and array, Pointers and strings, Double indirection.

Unit 4. Searching and Sorting

Searching Algorithms, Sorting Algorithms, Graphics in C.

Unit 5. Structures & File Handling

Why use structures, Declaring a structures, Accessing structures elements, How structures elements are stored, Array of structures, Additional features of structures, Uses of structures, Unions, Unions of structures, Structures and pointers, Files, Types of Disk I/O, Standard Input/output, Binary Mode and Text Mode, Record Input/Out, Random access, Error condition, System-level Input/output.

Recommended Books/Reference Material

5. Bin Uzayr, S. (2022). Mastering C++ Programming Language: A Beginner's Guide. CRC Press.
6. Deitel, H., & Deitel, P. C. (2021). How to program. Pearson.
7. Deitel, P., & Deitel, H. (2022). C++ 20 for Programmers: An Objects-Natural Approach. Pearson.
8. Doyle, B. (2014). C# Programming: from problem analysis to program design. Cengage Learning.
9. Gaddis, T. (2008). Starting Out with Programming Logic and Design, 2/e. Pearson Education India.
10. Gregoire, M. (2021). Professional C++. John Wiley & Sons.
11. Hanly, J. R., & Koffman, E. B. (2007). Problem solving and program design in C. Pearson Education India.
12. Lafore, R. (1997). Object-oriented programming in C++. Pearson Education.

Programming Fundamentals LAB

Course Code: CS-122L

Credit Hours: 01

Pre-requisite: Nil

Objectives

This course helps the students to understand basic knowledge of visual studio and computer programs and capable of designing different C language programs and flowcharts.

Learning Outcomes

- **Implement** fundamental knowledge and understanding of computer programming using C Language program constructs **(P2 Manipulation)**.
- **Demonstrate** the use of software tool, Microsoft Visual Studio for program development in C Language **(P3 Precision)**.
- **Apply** the knowledge of C programming to develop small-to-moderate scale software applications and use Visual Studio software tool for program testing and debugging **(P4 Articulation)**.
- **Execute** module-based approach to gratify those requirements, and organize program code for implementation **(P2 Manipulation)**.

Course Outline

Unit 1. Introduction to Framework

Installation of visual studio, Variable Declaration and Initialization, Programming Syntax, Decision Control structure (if statement, Multiple Statements within if, if-else statement, Nested if-else's).

Unit 2. Loops, Statements, Functions

Loops structure (while, do while, for loop), break statement, continue statement, goto statement, case control structure, Decisions using switch, Function, User & system defined functions, Parameters, arguments, Passing values between functions, Call by value and call by reference, Recursion , Fibonacci series.

Unit 3. Arrays & Pointers

Array initialization, Bounds checking, Passing array elements to functions, Passing an entire array to a function, More the one dimension, Initializing A 2-Dimensional array, Three Dimensional arrays, Puppeting on string, Return data from function, Pointer and array, Pointers and strings, Double indirection, Pointers to pointers.

Unit 4. Searching and Sorting

Searching Algorithms, Sorting Algorithms, Graphics in C.

Unit 5. Structures & File Handling

Declaring a structures, Accessing structures elements, How structures elements are stored, Array of structures, Uses of structures, Unions, Unions of structures, Structures and pointers, Files, Standard Input/output, Binary Mode and Text Mode, Record Input/Out.

Recommended Books/Reference Material

1. Bin Uzayr, S. (2022). Mastering C++ Programming Language: A Beginner's Guide. CRC Press.

2. Deitel, P., & Deitel, H. (2022). C++ 20 for Programmers: An Objects-Natural Approach. Pearson.
3. Doyle, B. (2014). C# Programming: from problem analysis to program design. Cengage Learning.
4. Gaddis, T. (2008). Starting Out with Programming Logic and Design, 2/e. Pearson Education India.
5. Gregoire, M. (2021). Professional C++. John Wiley & Sons.
6. Hanly, J. R., & Koffman, E. B. (2007). Problem solving and program design in C. Pearson Education India.
7. Lafore, R. (1997). Object-oriented programming in C++. Pearson Education.
8. Weisfeld, M. (2008). The object-oriented thought process. Pearson Education.
- Wu, C. T. (2006). An Introduction to object-oriented programming with Java TM. Mcgraw-Hill Incorporated.

Fundamentals of Object-Oriented Programming

Program: BS Mathematics

Course Code: CS-111

Credit Hours: 2

Course Type: Interdisciplinary

Pre-requisite: Introduction to Programming (in C)

Objectives

This course introduces object-oriented programming using C++ to students with basic programming knowledge. It focuses on key OOP principles such as classes, encapsulation, inheritance, and polymorphism, with an emphasis on writing modular, reusable code for mathematical or scientific applications.

Learning Outcomes

- Understand core object-oriented programming principles (abstraction, encapsulation, inheritance, and polymorphism).
- Apply object-oriented design to develop structured and reusable code.

- Implement C++ programs using classes and objects.
- Write simple programs using constructors, inheritance, operator overloading, and file handling.

Course Outline:

Unit 1. Introduction to Object-Oriented Programming

OOP differs from the procedural paradigm by organizing code into objects and classes. It emphasizes encapsulation and abstraction, offering better modularity, reusability, and easier maintenance.

Unit 2. Classes and Objects in C++

Classes and objects are defined with member functions, constructors, and destructors, using access specifiers like public, private, and protected. The use of static and const members adds control and efficiency.

Unit 3. Inheritance and Polymorphism

Covers types of inheritance, function overriding, virtual functions, polymorphism, and an introduction to abstract classes and interfaces.

Unit 4. Operator Overloading and File Handling

Includes operator overloading basics, friend functions, simple file I/O, and a brief overview of templates and exception handling.

Recommended Books/Reference Material

1. Unit, I. OBJECT ORIENTED PROGRAMMING USING C+. *BACHELOR OF COMPUTER APPLICATIONS*.
2. Soto, W. (2025, March). Tool-Based Retrieval-Augmented Generative as an Automated Assistant in Object-Oriented Programming Course. In *2025 IEEE Engineering Education World Conference (EDUNINE)* (pp. 1-6). IEEE.

3. Mathew, S. S., Kuhail, M. A., Hadid, M., & Farooq, S. (2025). *The Object-Oriented Approach to Problem Solving and Machine Learning with Python*. CRC Press.

Fundamentals of Object-Oriented Programming LAB

Program: BS Mathematics

Course Code: CS-111L

Credit Hours: 1

Course Type: Interdisciplinary

Pre-requisite: Introduction to Programming (in C)

Objectives

This course introduces object-oriented programming using C++ to students with basic programming knowledge. It focuses on key OOP principles such as classes, encapsulation, inheritance, and polymorphism, with an emphasis on writing modular, reusable code for mathematical or scientific applications.

Learning Outcomes

- Understand core object-oriented programming principles (abstraction, encapsulation, inheritance, and polymorphism).
- Apply object-oriented design to develop structured and reusable code.
- Implement C++ programs using classes and objects.
- Write simple programs using constructors, inheritance, operator overloading, and file handling.

Course Outline

Unit 1. C++ Programming Environment

Writing basic object-oriented C++ programs, Compiling and debugging simple projects

Unit 2. Classes and Constructors

Includes programs with constructors, destructors, access modifiers, member functions, and use of static members.

Unit 3. Inheritance and Polymorphism

Covers implementation of single-level and multi-level inheritance, along with virtual functions and runtime polymorphism.

Unit 4. Operator Overloading & File Operations

Covers overloading basic operators like + and =, and reading/writing files using file streams.

Unit 5. Mini Project (Optional)

Small console-based project applying OOP concepts

Recommended Books / References

1. Deitel, P. & Deitel, H. (2016). *C++ How to Program* (10th ed.). Pearson.
2. Gaddis, T. (2017). *Starting Out with C++: From Control Structures to Objects* (9th ed.). Pearson.
3. Hanly, J. R., & Koffman, E. B. (2012). *Problem Solving and Program Design in C*. Pearson. (for review of pre-requisite concepts)
4. Stroustrup, B. (2013). *The C++ Programming Language* (4th ed.). Addison-Wesley. (optional)

Artificial Intelligence

Course Code: CS-206

Credit Hours: 02

Pre-requisite: Object Oriented Programming

Objectives

Artificial Intelligence (AI) is a constantly and actively growing and changing field. In this course, students will learn the basics of modern AI as well as some of the representative applications of AI. This course introduces students to the basic knowledge representation,

problem solving, and learning methods of artificial intelligence. Upon completion, students should be able to develop intelligent systems by assembling solutions to concrete computational problems; understand the role of knowledge representation, problem solving, and learning in intelligent-system engineering; and appreciate the role of problem solving, vision, and language in understanding human intelligence from a computational perspective.

Learning Outcomes

- Know various AI search algorithms (tree search, uninformed, informed, and heuristic), understand different types of AI agents, and know how to build simple knowledge-based systems.
- Ability to apply knowledge representation, reasoning, and machine learning techniques to real-world problems.

Course Outline

Unit 1. Introduction

What is AI, Major AI areas, Intelligent Agents: Agents and environments, Rationality? PEAS (Performance measure, Environment, Actuators, Sensors), Environment types, Agent Types, Problem solving through uninformed search: Breadth First Search, Depth First Search, Iterative DFS, Comparison of Search Algorithms.

Unit 2. Problem Solving Through Informed Search, Expert Systems

Problem solving through informed search: Heuristically Informed Methods, Hill Climbing, Beam Search, Best First Search, A*Procedure, Adversarial Search, Min-Max Procedure, Static Evaluation Function, Alpha Beta Pruning, Expert Systems: Knowledge Base Expert System Their Types and Application, Working of Expert Systems with its different components.

Unit 3. Neural Networks, Back Prop Algorithms

Binary Expert Systems: Developing an Expert System, Identifying the problem, forward and Backward Chaining. Neural Network: Introduction to Artificial Neural

Networks (ANN), ANN Applications, Topologies of ANN, Single Layer perception (SLP).

Unit 4. Genetic Algorithm, Fuzzy System, Classification

Genetic Algorithm: Introduction to Evolutionary Computing, Genetic Algorithm (GA), Genetic operators (Crossover and Mutation) and its applications. Fuzzy System: Fuzzy Set Theory, Fuzzy Inference, And Classification: Decision Tree, Bayes Classification

Unit 5. Machine Learning, Introduction to Computer Vision, Mining Frequent Patterns

Machine Learning: Introduction to Learning, Supervised Machine Learning: Unsupervised Learning, K-means Clustering Algorithm, and Introduction to Computer Vision (CV), Pattern Recognition, Mining Frequent Patterns, Association and Correlation.

Recommended Books/Reference Material

1. Finlay, J. (2020). An introduction to artificial intelligence. Crc Press.
2. Joshi, P. (2017). Artificial intelligence with python. Packt Publishing Ltd.
3. Le, D., Chung, K., Quach, S., & Thaichon, P. (2022). Introduction to artificial intelligence (AI). Artificial Intelligence for Marketing Management.
4. Luger, G. F. (2005). Artificial intelligence: structures and strategies for complex problem solving. Pearson education.
5. Mehrotra, D. (2019). Basics of artificial intelligence & machine learning. Notion Press.
6. Miller, B. N., Ranum, D. L., & Anderson, J. (2019). Python programming in context. Jones & Bartlett Learning.

Artificial Intelligence LAB

Course Code: CS-206L

Credit Hours: 01

Pre-requisite: Object Oriented Programming

Objectives

Study the applications of AI and agent-based approach to AI and First-order predicate calculus, logical reasoning and problem-solving using Prolog language. To study and discuss various techniques and algorithms of AI used in general problem solving, optimization problems, constraint satisfaction problems, and game programming. Familiarize students with various sub-areas of AI, such as expert systems, natural language processing and machine learning.

Learning Outcomes

- **Explain** artificial intelligence, its characteristics and its application areas (**C2 Understand**).
- **Formulate** real-world problems as state space problems, optimization problems or constraint satisfaction problems (**P4 Articulation**).
- **Implement** appropriate algorithms and AI techniques to solve complex problems (**P2 Manipulation**).
- **Develop** an expert system by using appropriate tools and techniques (**P4 Articulation**).

Course Outline

Unit 1. Problem Solving

Problem solving (2 jug puzzles, 3 jug puzzles, lion man puzzles, vacuum cleaner puzzle. Implementation of 2 jug puzzles, 3 jug puzzles, lion man puzzles, vacuum cleaner puzzle using DFS and BFS.

Unit 2. Cost Search Algorithm Implementation

Implementation of A* and Uniform cost search algorithms to solve problems. Implementation of different games using game search tree algorithms

Unit 3. Game Search Algorithm Implementation

Implementation of different games using game search tree algorithm Solution of 8 queen problem using genetic algorithm.

Unit 4. 8 Queen Problem and Prolog Language

Solution of 8 queen problem using genetic algorithm. Learning Prolog language for Logic Practice of Prolog and Lisp.

Unit 5. K Means Clustering Algorithm and Neural Networks

Implementation of K mean clustering algorithm. Implementation of single layer neural network.

Recommended Books/Reference Material

1. Finlay, J. (2020). An introduction to artificial intelligence. Crc Press.
2. Joshi, P. (2017). Artificial intelligence with python. Packt Publishing Ltd.
3. Le, D., Chung, K., Quach, S., & Thaichon, P. (2022). Introduction to artificial intelligence (AI). Artificial Intelligence for Marketing Management.
4. Luger, G. F. (2005). Artificial intelligence: structures and strategies for complex problem solving. Pearson education.
5. Mehrotra, D. (2019). Basics of artificial intelligence & machine learning. Notion Press.
6. Miller, B. N., Ranum, D. L., & Anderson, J. (2019). Python programming in context. Jones & Bartlett Learning.

Game Development

BS-Computer Science

Course Code: CS-308

Credit Hours: 03

Pre-requisite: Nil

Objectives

Define the principles of game design and development. Gain programming capability to develop games. Learn to structure and define the duties of the game development team. Practice art creation, music and animations and various tools needed to create assets. Apply the mathematics and physics to game design. Apply basic artificial intelligence to developing computer games. Manage porting issues on various platforms.

Learning Outcomes

- **Understand** the concept of a Game Engine (**C2 Understand**).
- **Demonstrate** knowledge of the Unity Game Engine interface (**C3 Apply**).
- **Demonstrate** knowledge of the Integrated Development Environment (IDE) of computer programming (**C3 Apply**).
- **Demonstrate** knowledge of the various interface components that compromise the Integrated Development Environment (IDE) of Unity (**C3 Apply**).
- **Apply** the programming structure learned in Visual Basic language as a basis for learning JavaScript and C# scripting language to manage, manipulate, and animate the game objects in Unity (**C3 Apply**).

Course Outline

Unit 1. Introduction

Explore the world of Game Engines/Unity the game engine of choice/Unity Interface/Install Unity software. Layout and Creating Scenes/Transitions and Manipulation of Objects.

Unit 2. C# Programming: The Language of Choice

Introduction to C# programming language; creating your first script. Features to add to knowledge base: Sprite Renderer, Prefab creation, Collision Detection, Score management; Create a game environment – navigate camera, design play area, create & collect objects, display score, build the game.

Unit 3. Simple Movement and Input

Simple Movement, Simple Rotation and Scaling, Easy Input Handling in Unity, Parent-Child Objects, Sorting Layers, Tagging Game Objects, Collision Layers, Prefabs, Creating and Destroying Objects, Controlling Object Lifespans with Invoke.

Unit 4. Organizing Game Objects

Simple Movement, Simple Rotation and Scaling, Easy Input Handling in Unity, Parent-Child Objects, Sorting Layers, Tagging Game Objects, Collision Layers, Prefabs, Creating and Destroying Objects, Controlling Object Lifespans with Invoke.

Unit 5. Animation

Simple Unity Animation, Animator States, Scripting Animations, Animations and Colliders.

Recommended Books/Reference Material

1. Cossu, S. M. (2019). Game development with GameMaker Studio 2: Make your own games with gamemaker language. Apress.
2. Hautala, N. (2021). Creating Emotional VR Game Narrative: Experimental Game Design Research (Master's thesis).
3. Tarhan, A. K. (2022). Game Design as a Pedagogic Tool: The Future of STEM Education.

Digital Image Processing

BS-Computer Science

Course Code: CS-315

Credit Hours: 03

Pre-requisite: Nil

Objectives

To learn the fundamental concepts of Digital Image Processing. To study basic image processing operations. To understand image analysis algorithms. To expose students to current applications in the field of digital image processing.

Learning Outcomes

- **Develop and implement** algorithms for digital image processing (**C6 Create**).
- **Apply** image processing algorithms for practical object recognition applications (**C3 Apply**).

Course Outline

Unit 1. Introduction

The human visual system, electromagnetic system, working and components inside digital camera, pixels.

Unit 2. Image representation

Image representation, sampling, quantization, mathematics of image formation, convolution, camera projection.

Unit 3. Image Processing

Point-based image processing, Fourier theory, image filtering in spatial and frequency domain, wavelets, image registration documentation,

Unit 4. Morphological operations and Feature Detection

Morphological operations, color models, multispectral images, feature detection.

Unit 5. Image Segmentation

Point, Line, and Edge Detection, Thresholding, Region-Based Segmentation ,implementation in Matlab, Segmentation Using Morphological Watersheds Object recognition, Descriptors: boundaries, regions, global Pattern recognition as applied to images, Object/scene/activity categorization, Object detection, Supervised classification algorithms, Probabilistic models for sequence data, Deep learning, convolutional neural networks Visual attributes, Active learning ,Dimensionality reduction ,Non-parametric methods and big data.

Recommended Books/Reference Material

1. Thanki, R. M., & Kothari, A. M. (2019). Digital image processing using SCILAB. Springer International Publishing.
2. Umbaugh, S. E. (2022). Digital Image Processing and Analysis: Digital Image Enhancement, Restoration and Compression. Crc Press.
3. Umbaugh, S. E. (2023). Digital image processing and analysis: computer vision and image analysis. CRC Press.

Theory of Automata

Course Code: CS-317

Credit Hours: 03

Pre-requisite: Nil

Objectives

Unlike most courses in Computer Science, this course is not directly about programming. Rather, it introduces some of the models, like automata and grammars that are useful in many applications. The theories of undecidability and intractability are there to remind us that there are certain things we would like to solve by computation, but which are either impossible (undecidable) or are possible but cannot be solved efficiently (intractable).

Learning Outcomes

- **Design** and derivation of regular languages using mathematical models **(C6 Create)**.
- **Design** and derivation of non-regular languages using mathematical models **(C6 Create)**.
- **Design** of Turing Machine **(C6 Create)**.

Course Outline

Unit 1. Introduction to Finite Automata and Regular Expressions

Language definitions preliminaries, Descriptive Method, Regular expressions, Finite Automata, NFA, DFA, Transition graphs, TG to RE, Kleene's theorem, Union, Intersection & Complement of FA, DFA Minimization, Transducers (Mealy Machine, Moore Machine), Conversions

Unit 2. Regular Languages

Regular languages vs Non regular languages, Properties of regular languages, Pumping Lemma, Decision properties: membership, equivalence, emptiness, finiteness, containment. Closure properties: union, concatenation, complementation, intersection, reversal, homomorphism and inverse homomorphism.

Unit 3. Context Free Grammars

Context free grammars, Derivations, derivation trees and ambiguity. Simplifying CFL, Normal form grammars and parsing, Decidability.

Unit 4. Pushdown Automata

Push Down Automata, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars, Conversion of PDA and CFG.

Unit 5. Turing Machines

Turing Machines Theory, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Recommended Books/Reference Material

1. Automata theory and computability. (2021). (n.p.): Book Rivers.
2. Cohen, D. I. A. (1997). Introduction to computer theory. United Kingdom: Wiley.
3. Education.Homenda, W., Pedrycz, W. (2022). Automata Theory and Formal Languages. Germany: De Gruyter.
4. Hopcroft, J. E. (2008). Introduction to Automata Theory, Languages, and Computation. India: Pearson
5. Linz, P. (2006). An Introduction to Formal Languages and Automata. United Kingdom: Jones and Bartlett Publishers.
6. Rich, E. (2007). Automata, Computability and Complexity. United Kingdom: Pearson Prentice Hall.

HCI and Computer Graphics

BS-Computer Science

Course Code: CS-322

Credit Hours: 02

Pre-requisite: Nil

Objectives

In this course, students will learn about some of the advanced and emerging topics in 3D graphics along with the classic graphics algorithms and the standard phases in the graphics pipeline. This course covers 3D graphics concepts like transformation, projections and rendering. Course topics include both the mathematical as well as technical aspects of developing graphics.

Learning Outcomes

- **Understand** and be familiar with current concepts in 3d graphics, along with the basic workflow of the graphics pipeline (**C2 Understand**).
- **Implement** basic graphics related Algorithms and techniques to create and manipulate 3d graphics (**C3 Apply**).
- **Create** a simple 3D game in Unit 3d and be familiar with the basics of game development (**C6 Create**).

Course Outline

Unit 1. Introduction to HCI and Color Models

Introduction to HCI. History and Usages CRT (Cathode Ray Tube) devices: DVST. Color Models: Pseudo Colors, True Colors, High colors and Deep colors. Human Cognition, Importance of Color models in visual perception. Color Modes: Additive and Subtractive. Metrics and Measures for Evaluation of the Interface.

Unit 2. Transformations and Projections

Transformations: 2D, 3D, HCS and Composite Transformations. Projection: Affine and Solid Body. Usability heuristics and principles of Usability testing. World window to Viewport Transformations. Principles of good interaction design.

Unit 3. Line Drawing and Clipping Algorithms

Line Drawing Algorithms: DDA (Digital differential algorithm). Bresenham's Line Drawing Algorithm. Clipping Algorithms: Cohen Sutherland Clipping Algorithm. Sutherland Hodgeman Clipping Algorithm.

Unit 4. Filling Algorithms

Filling Algorithms: Scanline Filling Algorithm. 8-point filling Algorithm & 4-Point Filling Algorithm.

Unit 5. Rendering, Lighting and Shading

Rendering: Forward and backward rendering and rendering in Nature, Vectors and 3d Geometry. Usability inspection methods, Usability testing methods. Lighting and Shading Interaction Technologies, Usability in practice.

Unit 6. Polynomial Curves and Surfaces

Polynomial curves and surfaces, approximation techniques such as polynomial curves, bezier curves, spline curves and surfaces, animation as a sequence of still images. Visual Design and Typography, Icon Design. Ellipse and other Curves.

Recommended Books/Reference Material

1. Akenine-Moller, T., Haines, E., & Hoffman, N. (2019). Real-time rendering. AK Peters/crc Press.
2. Gordon, V. S., & Clevenger, J. L. (2020). Computer graphics programming in OpenGL with C++. Mercury Learning and Information.
3. Clevenger, J. L., & Gordon, V. S. (2021). Computer Graphics Programming in OpenGL with C+. Mercury Learning.
4. Kosarevsky, S., & Latypov, V. (2021). 3D Graphics Rendering Cookbook: A comprehensive guide to exploring rendering algorithms in modern OpenGL and Vulkan. Packt Publishing Ltd.

HCI and Computer Graphics LAB

BS-Computer Science

Course Code: CS-322L

Credit Hours: 01

Pre-requisite: Nil

Objectives

In this course, students will learn about some of the advanced and emerging topics in 3D graphics along with the classic graphics algorithms and the standard phases in the graphics pipeline. This course covers 3d graphics concepts like transformation, projections and rendering. Course topics include both the mathematical as well as technical aspects of developing graphics.

Learning Outcomes

The students will be able to

- **Create** a 3D model in any modelling tool, light and shade it, add texture to it etc. and create a photorealistic scene **(P5 Naturalization)**.
- **Create** programs in OpenGL using any library **(P5 Naturalization)**.
- **Create** work based on the HCI guidelines **(P5 Naturalization)**.

Course Outline

Unit 1. Introduction to HCI and Color Models

Introduction to HCI. History and Usages CRT (Cathode Ray Tube) devices: DVST. Color Models: Pseudo Colors, True Colors, High colors and Deep colors. Human Cognition, Importance of Color models in visual perception. Color Modes: Additive and Subtractive. Metrics and Measures for Evaluation of the Interface.

Unit 2. Transformations and Projections

Transformations: 2D, 3D, HCS and Composite Transformations. Projection: Affine and Solid Body. Usability heuristics and principles of Usability testing. World window to Viewport Transformations. Principles of good interaction design.

Unit 3. Line drawing and Clipping Algorithms

Line Drawing Algorithms: DDA (Digital differential algorithm). Bresenham's Line Drawing Algorithm. Clipping Algorithms: Cohen Sutherland Clipping Algorithm. Sutherland Hodgeman Clipping Algorithm.

Unit 4. Filling Algorithms

Filling Algorithms: Scanline Filling Algorithm. 8-point filling Algorithm & 4-Point Filling Algorithm.

Unit 5. Rendering, Lighting and Shading

Basic rendering: rendering in nature, i.e., the emission and scattering of light and its relation to numerical integration, affine and coordinate system transformations, ray tracing, visibility and occlusion, including solutions to this problem such as depth buffering, painter's algorithm, and ray tracing, the forward and backward rendering equation. Usability inspection methods, Usability testing methods. Lighting and Shading Interaction Technologies, Usability in practice.

Unit 6. Polynomial Curves and Surfaces

Polynomial curves and surfaces, approximation techniques such as polynomial curves, bezier curves, spline curves and surfaces, animation as a sequence of still images. Visual Design and Typography, Icon Design. Ellipse and other Curves.

Recommended Books/Reference Material

1. Akenine-Moller, T., Haines, E., & Hoffman, N. (2019). Real-time rendering. AK Peters/crc Press.
2. Gordon, V. S., & Clevenger, J. L. (2020). Computer graphics programming in OpenGL with C++. Mercury Learning and Information.
3. Clevenger, J. L., & Gordon, V. S. (2021). Computer Graphics Programming in OpenGL with C+. Mercury Learning.
4. Kosarevsky, S., & Latypov, V. (2021). 3D Graphics Rendering Cookbook: A comprehensive guide to exploring rendering algorithms in modern OpenGL and Vulkan. Packt Publishing Ltd.

Data Science

BS-Computer Science

Course Code: CS-404

Credit Hours: 03

Pre-requisite: Nil

Objectives

The Data Science course offers: In-depth knowledge of Data Science Life Cycle and Machine Learning Algorithms. Comprehensive knowledge of various tools and techniques for Data Transformation. The capability to perform Text Mining and Sentimental analyses on text data and gain an insight into Data Visualization and Optimization techniques. The exposure too many real-life industry-based projects which will be executed in R Studio and python. Projects which are diverse in nature covering media, healthcare, social media, aviation and HR. Rigorous involvement of an SME throughout the Data Science Training to learn industry standards and best practices.

Learning Outcomes

- **Implement** Text Mining and Sentimental analyses on text data and gain an insight into Data Visualization and Optimization techniques **(C3 Apply)**.
- **Implement** many real-life industry-based projects which will be executed in R Studio and python **(C3 Apply)**.

Course Outline

Unit 1. Introduction to Data Science

Introduction: What is Data Science? Big Data and Data Science hype – and getting past the hype, Exploratory Data Analysis and the Data Science Process, Exploratory Data Analysis: Basic tools (plots, graphs and summary statistics) of EDA, Philosophy of EDA. Exploratory Data Analysis: The Data Science Process, Case Study: Real Direct (online real estate firm), Statistical Inference: Populations and samples, Statistical Inference: Statistical modeling, probability distributions, fitting a model.

Unit 2. Data Visualization

Statistical Inference: Intro to R and Python , Data Visualization: Basic principles, ideas and tools for data visualization , Data Visualization: Examples of inspiring (industry) projects- Exercise: create your own visualization of a complex dataset , Introduction to machine learning: Linear regression and regularization ,

Introduction to machine learning Model selection and evaluation , Classification: decision trees, SVM, kNN, Ensemble methods: random forests, Intro to probability: Naïve Bayes and logistic regression.

Unit 3. Clustering, Machine Learning Algorithms

Clustering: k-means, hierarchical clustering, Dimensionality reduction: PCA and SVD. One More Machine Learning Algorithm and Usage in Applications Motivating application: Filtering Spam, Why Linear Regression and k-NN are poor choices for Filtering Spam, Naive Bayes and why it works for Filtering Spam, Data Wrangling: APIs and other tools for scrapping the Web, Feature Generation and Feature Selection (Extracting Meaning from Data).

Unit 4. Features Generations, Text Mining and Recommendation Systems

Feature Generation (brainstorming, role of domain expertise, and place for imagination). Feature Selection algorithms, Filters; Wrappers; Decision Trees; Random Forests, Text mining and information retrieval, Recommendation Systems: Building a User-Facing Data Product, Recommendation Systems: Algorithmic ingredients of a Recommendation Engine, Recommendation Systems: build your own recommendation system.

Unit 5. Mining Social-Network Graphs, Big Data, & Data Science and Ethical Issues

Mining Social-Network Graphs Mining Social-Network Graphs: Clustering of graphs, Direct discovery of communities in graphs, Big Data: Big data storage and retrieval, Big data distributed computing, Data Science and Ethical Issues Discussions on privacy, security, ethics, A look back at Data Science, Next-generation data scientists Recommended Books/Reference Material.

Recommended Books/Reference Material

1. Bruce, P., Bruce, A., & Gedeck, P. (2020). Practical statistics for data scientists: 50+ essential concepts using R and Python. O'Reilly Media.

2. Efron, B., & Hastie, T. (2021). Computer age statistical inference, student edition: algorithms, evidence, and data science (Vol. 6). Cambridge University Press.
3. Kabacoff, R. (2022). R in action: data analysis and graphics with R and Tidyverse. Simon and Schuster.
4. Wickham, H., Çetinkaya-Rundel, M., & Grolemund, G. (2023). R for data science. "O'Reilly Media, Inc."

Cloud Computing

BS-Computer Science

Course Code: CS-406

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course introduces students to fundamentals of cloud computing and software development for cloud platforms. It covers topics such as cloud basic architecture, virtualization, and architecture of cloud systems, programming for the cloud, resource management, as well as privacy and security issues.

Learning Outcomes

- **Apply** vSphere. OpenStack, Microsoft Azure Cloud (**C3 Apply**).
- **Practice** vSphere. OpenStack, o Microsoft Azure Cloud (**A5 Internalizing**).
- **Contribute** individually or as a team member to work effectively (**C2 Respond**).

Course Outline

Unit 1. Introduction vSphere Virtual Infrastructure

Introduction vSphere Virtual Infrastructure, Overview of vSphere virtual infrastructure Installation of ESXi, Configuring ESXi services. VSphere Virtual

Infrastructure. Discuss the latest virtual machine hardware and its features, Explain the importance of VMware Tools™, Deploy and configure virtual machines and templates, Identify virtual machine disk format. Describe, create, and manage standard switches, Configure virtual switch security and load-balancing policies, explain the importance of VMware Tools™, Describe the virtual switch connection types.

Unit 2. Configuring and Managing Virtual Storage

Introduce storage protocols and storage device types. Create and manage VMFS and NFS datastores, describe the new features of VMFS 6.7. Deploy and configure vCenter Server Appliance, use vSphere Web Client, Backup and restore vCenter Server, vCenter Server permissions and roles. Compute, Storage and Network Management, OpenStack Orchestration Management, Image Management. Use templates and cloning to deploy new virtual machines, Modify and manage virtual machines, Clone a virtual machine, Remove virtual machines from the vCenter Server inventory and datastore.

Unit 3. Introduction to Microsoft Azure Cloud

Azure Foundations ,Azure Portal, Azure CLI, Cloud Shell , Creating a Free Azure Account , Footprint and Structure ,Azure Services ,Web and Mobile , Databases , Data and Analytics ,Security and Identity , Monitoring and Management . Creating Azure Resources. App Service, Azure Container Instances, Azure App Services

Unit 4. Networking – Azure

Creating a Virtual Network Connection, IP Addressing, Azure Active Directory, Create Azure AD Tenant, Create Users and Groups, Self-Service Password Reset, Creating a Storage Account, Add Disk, Disk Caching.

Unit 5. Introduction to Cloud Computing

Introduction to cloud computing, Cloud security threats and vulnerabilities, Cloud security models (SaaS, PaaS, IaaS), Cloud security technologies and tools. Mobile device security threats, Mobile device management (MDM), secure mobile application development, Mobile data encryption.

Recommended Books/Reference Material

1. Gavanda, M., Mauro, A., Valsecchi, P., & Novak, K. (2019). *Mastering VMware vSphere 6.7: Effectively deploy, manage, and monitor your virtual datacenter with VMware vSphere 6.7*. Packt Publishing Ltd.
2. Ruparelia, N. B. (2023). *Cloud computing*. Mit Press.
3. Toroman, M. (2018). *Hands-On Cloud Administration in Azure: Implement, monitor, and manage important Azure services and components including IaaS and PaaS*. Packt Publishing Ltd.
4. Trofimczuk, D., Ahola, H., & Aunimo, L. (2022). Case study: Microsoft Azure Cloud experiences in teaching at Haaga-Helia University of Applied Sciences.

Mobile Application Development

Course Code: CS-408

Credit Hours: 2

Pre-requisite: Nil

Objectives

The main objective of mobile development is creating applications and any other kind of software specific to mobile devices, including tablets. Mobile development seeks to optimize functionality and user experience on mobile devices, as there are important differences between mobile and desktop UX. This course aims to introduce students to the following concepts and cognitive skills.

Learning Outcomes

- **Understand** the life cycle of android applications **(C2 Understand)**.

- **Design** interactive interface for mobile applications using various layouts (**C6 Create**).
- **Develop** mobile applications for comprehensive systems using latest trends and practices (**C6 Create**).

Course Outline

Unit 1. Introduction

Mobile Application Development Platforms, System installation (Android Studio) , Android Architecture and framework, What is Android, The various Android devices on the market, The Android Market application store, How to develop your first Android application ,Components of Android Project (Application Structure), Using code Completion Debugging Application, What activities are?

Unit 2. Android Studio Layout Editor

Android Studio Layout editor, component tree, Constraint view, layout properties, Activities, Layouts, layout attributes, Views. View Groups, layout Orientation, XML, files (string, colors, values, dimen) in the project, Resource folders, Intents in Android, Calling build in intents, communication between activities.

Unit 3. Fragments

Display Notifications, Design interface with views, Displaying Pictures and menus with views .Data Persistence, Content providers, Messages (SMS, EMAIL), Location based services (Maps).

Unit 4. Networking

Establishing an HTTP Connection, Consuming Web Services using ,HTTP, Consuming JSON Services , Android Services, Create Own Services, Establishing Communication between a Service and an Activity ,Binding Activities to Services, Understanding Threading.

Unit 5. Architecture and Frameworks

Introduction to iOS Architecture and framework, Introduction to Xamarin/Flutter for cross platform development , Publishing, Android Applications, Mobile Programming Languages, Emerging Technologies.

Recommended Books /Reference Material

1. AFREEN, C. F. (2021). Mobile Applications Development. Book Rivers.
2. Android Programming: The Big Nerd Ranch Guides, Phillips, B. & Hardy, B., 3rd Edition (2017).
3. Burd, B., & Mueller, J. P. (2020). Android application development all-in-one for dummies. John Wiley & Sons.
4. iOS Programming: The Big Nerd Ranch Guide, Conway, J., Hillegass, A., & Keur, C., 5th Edition (2015).
5. Lewis, S., & Dunn, M. (2019). Native mobile development: a cross-reference for iOS and Android. O'Reilly Media.
6. Professional Android Application Development, Reto Meier, Wrox Programmer to Programmer, 3rd Edition (2014).

Mobile Application Development LAB

Course Code: CS-408L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Objective of mobile development is creating applications and any other kind of software specific to mobile devices, including tablets. Mobile development seeks to optimize functionality and user experience on mobile devices, as there are important differences between mobile and desktop UX. This course aims to introduce students to the following concepts and cognitive skills.

Learning Outcomes

- **Develop** programs using fundamental concepts of mobile application development (**P4 Articulation**).
- **Manipulate** the use of Android Studio for making mobile applications (**P2 Manipulation**).
- **Manipulate** the use of any technology to create a mobile application with database connectivity (**P2 Manipulation**).

Course Outline

Unit 1. Introduction

Mobiles Application Development Platform, Android OS: Architecture, Framework and Application Development.

Unit 2. iOS

Architecture, Framework; Application Development with Windows Mobile; Eclipse; Fragments; Calling Built-in Applications using Intents; Displaying Notifications; Components of a Screen; Adapting to Display Orientation; Managing Changes to Screen Orientation; Utilizing the Action Bar.

Unit 3. Interfacing

Creating the User Interface; Listening for UI Notifications; Views; User Preferences; Persisting Data; Sharing Data; Sending SMS Messages; Getting Feedback; Sending E-mail; Displaying Maps; Consuming Web Services Using HTTP; Web Services: Accessing and Creating; Threading; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages; Challenges with Mobility and Wireless Communication; Location-aware Applications; Performance/Power Tradeoffs; Mobile Platform Constraints.

Unit 4. Emerging Technologies.

Introduction to Xamarin/Flutter for cross platform development, Publishing, Android Applications. Creating the User Interface; Listening for UI Notifications;

Views; User Preferences; Persisting Data; Sharing Data; Sending SMS Messages; Getting Feedback; Sending E-mail; Displaying Maps; Consuming Web Services Using HTTP; Web Services: Accessing and Creating; Threading; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages; Challenges with Mobility and Wireless Communication; Location-aware Applications; Performance/Power Tradeoffs; Mobile Platform Constraints.

Unit 5. Emerging Technologies.

Introduction to Xamarin/Flutter for cross platform development, Publishing, Android Applications.

Recommended Books /Reference Material

1. AFREEN, C. F. (2021). Mobile Applications Development. Book Rivers.
2. Android Programming: The Big Nerd Ranch Guides, Phillips, B. & Hardy, B., 3rd Edition (2017).
3. Burd, B., & Mueller, J. P. (2020). Android application development all-in-one for dummies. John Wiley & Sons.
4. iOS Programming: The Big Nerd Ranch Guide, Conway, J., Hillegass, A., & Keur, C., 5th Edition (2015).
5. Lewis, S., & Dunn, M. (2019). Native mobile development: a cross-reference for iOS and Android. O'Reilly Media.
6. Professional Android Application Development, Reto Meier, Wrox Programmer to Programmer, 3rd Edition (2014).

Web Engineering

Course Code: CS-407

Credit Hours: 02

Pre-requisite: Nil

Objectives

Web engineering focuses on the methodologies, techniques, and tools that are the foundation of Web application development and which support their design, development, evolution, and evaluation.

Learning Outcomes

- **Discuss** how web standards impact software development (**C2 Understand**).
- **Describe** the constraints that the web puts on developers (**C2 Understand**).
- **Design** a simple web application (**C6 Create**).
- **Support** an existing web application against a current web standard (**C5 Evaluate**).

Course Outline

Unit 1. Introduction

Introduction to Web programming languages (e.g., HTML5, CSS 3, Java Script, PHP/JSP/ASP.Net)

Unit 2. Design Principles of Web Based Applications

Design principles of Web based applications, Web platform constraints, Software as a Service (SaaS), Web standards, Responsive Web Design.

Unit 3. Web Applications

Web Applications, Browser/Server Communication, Storage Tier, Cookies and Sessions, Input Validation, Full stack state management, Web App Security - Browser Isolation.

Unit 4. Network Attacks

Network attack, Session Attacks, Large scale applications, Performance of Web Applications, Data Centers, Web Testing and Web Maintenance.

Unit 5. Laravel and ReactJs

Introduction to Laravel, Routes and Controllers. Views in Laravel and Blade templating engine. Databases, Eloquent, Models, Migrations, Seeders and Faker Factory. User authentication and authorization. Laravel - RESTful APIs authentication. React Basics, ReactDOM and JSX. Props, States and Components. Redux. React Router. Consuming RESTful APIs created in Laravel.

Recommended Books/Reference Material

1. An, K., & Tilevich, E. (2021, May). Communicating web vessels: Improving the responsiveness of mobile web apps with adaptive redistribution. In International Conference on Web Engineering (pp. 388-403). Cham: Springer International Publishing.
2. Chopra, R. (2016). Web Engineering. PHI Learning Pvt. Ltd...
3. Chopra, R., Kapoor, K., Madan, S., & Sibal, R. (2020). Improving quality of web applications deployed on cloud. Journal of Information and Optimization Sciences, 41(6), 1299-1308.
4. Mendes, E., & Mosley, N. (Eds.). (2006). Web engineering. Springer Science & Business Media.
5. Pressman, R., & Lowe, D. (2008). Web Engineering: A practioner's approach. McGraw-Hill, Inc.

Web Engineering LAB

Course Code: CS-407L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Web engineering focuses on the methodologies, techniques, and tools that are the foundation of Web application development and which support their design, development, evolution, and evaluation

Learning Outcomes

- **Discuss** how web standards impact software development (**C2 Understand**).
- **Describe** the constraints that the web puts on developers (**C2 Understand**).
- **Design** a simple web application (**P5 Naturalization**).
- **Execute** an existing web application against a current web standard (**P2 Manipulation**).

Course Outline

Unit 1. Introduction

Introduction to Web programming languages (e.g., HTML5, CSS 3, Java Script, PHP/JSP/ASP.Net)

Unit 2. Design Principles of Web Based Applications

Design principles of Web based applications, Web platform constraints, Software as a Service (SaaS), Web standards, Responsive Web Design.

Unit 3. Web Applications

Introduction to 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, XHTML MP. Web Service: SOAP, REST, WML, XSL. Web Services: Operations, Processing HTTP Requests, Processing HTTP Responses, Cookie Coordination, Privacy and P3P, Complex HTTP Interactions, Dynamic Content Delivery. Server Configuration. Server Security. Web Applications, Browser/Server Communication, Storage Tier, Cookies and Sessions, Input Validation, Full stack state management, Web App Security - Browser Isolation.

Unit 4. Network Attacks

Network attack, Session Attacks, Large scale applications, Performance of Web Applications, Data Centers, Web Testing and Web Maintenance.

Unit 5. Laravel and ReactJs

Introduction to Laravel, Routes and Controllers. Views in Laravel and Blade templating engine. Databases, Eloquent, Models, Migrations, Seeders and Faker Factory. User authentication and authorization. Laravel - RESTful APIs authentication. React Basics, ReactDOM and JSX. Props, States and Components. Redux. React Router. Consuming RESTful APIs created in Laravel.

Recommended Books/Reference Material

1. An, K., & Tilevich, E. (2021, May). Communicating web vessels: Improving the responsiveness of mobile web apps with adaptive redistribution. In International Conference on Web Engineering (pp. 388-403). Cham: Springer International Publishing.
2. Chopra, R. (2016). Web Engineering. PHI Learning Pvt. Ltd...
3. Chopra, R., Kapoor, K., Madan, S., & Sibal, R. (2020). Improving quality of web applications deployed on cloud. Journal of Information and Optimization Sciences, 41(6), 1299-1308.
4. Mendes, E., & Mosley, N. (Eds.). (2006). Web engineering. Springer Science & Business Media.
5. Pressman, R., & Lowe, D. (2008). Web Engineering: A practioner's approach. McGraw-Hill, Inc.

Introduction to Data Science

BS-CS

Course Code: CS-113

Course Type: Interdisciplinary

Credit Hours: 2

Pre-requisite: Nil

Objectives

The Data Science course offers:

- In-depth knowledge of Data Science Life Cycle and Machine Learning Algorithms.
Comprehensive knowledge of various tools and techniques for Data Transformation

Learning Outcomes

After completion of this course, students should be able to

- Master fundamental Python programming concepts and efficiently use development environments for mathematical programming.
- Utilize libraries such as Matplotlib, NumPy, SciPy, SymPy and Pandas to perform and visualize advanced mathematical computations.
- Apply mathematical programming techniques to analyze and solve real-world problems.

Course Outlines

Unit1. Introduction to Data Science

What is Data Science? Factors making data science ubiquitous.

Applications of data science in the domains of social media, banking, e-commerce, web-based search engines, travelling, health care, automation, credit and insurance.

Unit2. Six Phases of Data Science Life Cycle

Business Problem, Data Acquisition, Data Processing, Exploratory Data Analysis (EDA) and Visualization, Machine Learning (ML) Model Creation-Training-Evaluation, Deployment and Monitoring. Industry job roles and salary trends in data science domain.

Uni3. Basics of Python Programming

History of Python, Overview of mathematical programming, Installing and using a Python development environment (Jupyter note book/CoLab). Python syntax and semantics, Data types and variables Control structures (loops, conditionals), functions, Modules and packages.

Unit4. Container Types

Lists, Arrays, Tuples, Dictionaries, Sets, Container conversions.

Unit5. Python Libraries for Data Science

The matplotlib Library: Basic plotting with Matplotlib, Customizing plots (titles, labels, legends), Subplots and multiple plots 3D plotting and other advanced visualizations.

The numpy Library: NumPy arrays and operations, Mathematical functions in NumPy, Array manipulations and broadcasting, Linear algebra operations with NumPy, Universal functions.

The scipy Library: Key submodules in SciPy (optimize, integrate, interpolate, etc.), Numerical integration, Interpolation techniques, optimization problems, Differential equations.

The sympy Library: Basic elements of SymPy, Symbolic Linear Algebra, Calculus with sympy, Graphics in sympy, Three dimensional Graphs.

The Pandas Library: Series and DataFrames, Data manipulation and cleaning with Pandas, Merging, joining, and concatenating DataFrames, Grouping and aggregating data.

Unit6. Mathematics for Data Science

Probability & Statistics, Differential Calculus, Linear Algebra.

Recommended Books/Reference Material

1. Cielen, D., Meysman, A., and Ali, M., *Introducing Data Science*, Manning, 1st Edition, 2016.
2. Dietel, P. and Dietel, H., *Python for Programmers*, Pearson, 2019.
3. Führer, C., J. E. Solem, and Verdier, O., *Scientific Computing with Python 3*, Packt Publishing, 2nd edition, 2021.
4. Johansson, R., Urayasu-shi, Chiba, *Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib*, Pearson, 4th edition, 2017.
5. Hazrat, R., *A Course in Python*, Springer, 2023.
6. Seroul, R., *Programming for Mathematicians*, Springer, 2000.

Introduction to Data Science (Lab)

BS-CS

Course Code: CS-113L

Course Type: Interdisciplinary

Credit Hours: 1

Pre-requisite: Nil

Objectives

The Data Science course offers:

- In-depth knowledge of Data Science Life Cycle and Machine Learning Algorithms.
Comprehensive knowledge of various tools and techniques for Data Transformation.

Learning Outcomes

After completion of this course, students should be able to

- Master fundamental Python programming concepts and efficiently use development environments for mathematical programming.
- Utilize libraries such as Matplotlib, NumPy, SciPy, SymPy and Pandas to perform and visualize advanced mathematical computations.
- Apply mathematical programming techniques to analyze and solve real-world problems.

Course Outlines

Unit1. Introduction to Data Science Lab

Computer implementation on applications of data science in the domains of social media, banking, e-commerce, web-based search engines, travelling, health care, automation, credit and insurance.

Unit2. Six Phases of Data Science Life Cycle Lab

Business Problem computer lab, Data Acquisition, Data Processing, Exploratory Data Analysis (EDA) and Visualization, Machine Learning (ML) Model Creation-

Training- Evaluation, Deployment and Monitoring. Industry related problems such as job roles and salary trends in data science domain.

Uni3. Basics of Python Programming Lab

Practical of mathematical programming, Installing and using a Python development environment (Jupyter note book/CoLab). Python syntax and semantics, Data types and variables Control structures (loops, conditionals), functions, Modules and packages.

Unit4. Container Types Lab

Lists, Arrays, Tuples, Dictionaries, Sets, Container conversions.

Unit5. Python Libraries for Data Science Lab

The matplotlib Library: Basic plotting with Matplotlib, Customizing plots (titles, labels, legends), Subplots and multiple plots 3D plotting and other advanced visualizations.

The numpy Library: NumPy arrays and operations, Mathematical functions in NumPy, Array manipulations and broadcasting, Linear algebra operations with NumPy, Universal functions.

The scipy Library: Key submodules in SciPy (optimize, integrate, interpolate, etc.), Numerical integration, Interpolation techniques, optimization problems, Differential equations.

The sympy Library: Basic elements of SymPy, Symbolic Linear Algebra, Calculus with sympy, Graphics in sympy, Three dimensional Graphs.

The Pandas Library: Series and DataFrames, Data manipulation and cleaning with Pandas, Merging, joining, and concatenating DataFrames, Grouping and aggregating data.

Unit6. Mathematics for Data Science Lab

Probability & Statistics, Differential Calculus, Linear Algebra.

Recommended Books/Reference Material

1. Cielen, D., Meysman, A., and Ali, M., *Introducing Data Science*, Manning, 1st Edition, 2016.
2. Dietel, P. and Dietel, H., *Python for Programmers*, Pearson, 2019.
3. Fuhrer, C., J. E. Solem, and Verdier, O., *Scientific Computing with Python 3*, Packt Publishing, 2nd edition, 2021.
4. Johansson, R., Urayasu-shi, Chiba, *Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib*, Pearson, 4th edition, 2017.
5. Hazrat, R., *A Course in Python*, Springer, 2023.
6. Seroul, R., *Programming for Mathematicians*, Springer, 2000.

Course Outlines BS Mathematics with Finance

International Finance

Course Code: FIN-411

Credit Hours: 03

Pre-requisite: Nil

Objectives

Students examine the international aspects of corporate finance and investing. Topics include the international monetary system, balance of payments, the market for foreign exchange, international parity relationships and forecasting foreign exchange rates, international banking and money markets, international bond and equity market, futures and options on foreign exchanges, interest rate and currency swaps, international portfolio investment, and management of exposure.

Learning Outcomes

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

- Analyze the operations of international financial markets including past and present exchange rate systems.
- Clarify the concept of balance of payments and how it helps to forecast exchange rates.
- Explain the exposures of MNCs and non-MNCs in terms of operating, transaction and translation.

Course Outline

Unit 1. International Monetary System

History and the evolution of exchange rate systems. Flexible exchange rate regime. European monetary system. Fixed versus floating rate regimes. Balance of payments. Pakistan's balance of payments. Current and the capital account. External balance and the exchange rate

Unit 2. Foreign Exchange

Function and structure of the foreign exchange market. Determination of exchange rates. Setting the equilibrium spot exchange rate. Cross exchange rates and triangular arbitrage. Law of one price and the purchasing power parity. Interest rate parity. Fisher effect. Deviations from parity conditions. Forecasting exchange rates – fundamental and technical approaches

Unit 3. International Markets

International banking and money markets. Types of international banking offices. Offshore banking centers. Capital adequacy standards. International money markets. Eurocurrency, Euro credit and Euro notes. International financial crises. International bond and equity markets. Foreign and Eurobonds. Types of instruments. International bond credit ratings. Trading in international equities. Cross listing

Unit 4. Futures and Options

Futures and options on foreign exchange. Currency future markets. Speculating and hedging with currency futures. Eurodollar interest rate future contracts. Currency options – hedging and pricing issues. Interest rate and currency swaps. Type and size of the currency swap market. Swap banks. Quality spread differentials in an interest rate swap. Currency swaps and debt services. Variations of the basic interest rate and currency swaps. Risks in the swap market

Unit 5. International portfolio investment

Optimal international portfolio selection. International diversification – issues and tactics. International mutual funds. Country funds and ADRs. WEBS, hedge funds and home bias. Measurement of economic exposure. Operating exposure – illustration. Forward and money market hedge. Cross hedging minor currency exposures. Hedging contingent exposures. Methods of translation – current rate and temporal methods. Hedging translation exposure. Balance sheet hedges

Recommended Books/Reference Material

1. Banks, E. (2023). *Finance: the basics*. Taylor & Francis.
2. Eun, C. S., Breen, D. J., & Resnick, B. G. (2021). *International Financial Management: Canadian Perspectives*. McGraw-Hill Ryerson. (Latest edition)
3. Kevin, S. (2022). *Fundamentals of international financial management*. PHI Learning Pvt. Ltd.
4. Moffett, M. H., Stonehill, A. I., & Eiteman, D. K. (2021). *Fundamentals of multinational finance*. Pearson.
5. Pilbeam, K. (2023). *International finance*. Bloomsbury Publishing.

Financial Statement Analysis

Course Code: FIN-412

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to enable the students understanding the financial statements of businesses in detailed manner. It enables the students to utilize the published financial information of the corporations for analysis purposes. It facilitates the students to develop a thorough understanding and ways to analyze the financial data of different kinds of corporations especially for problem solving and decision-making purposes.

Learning Outcomes

- Having an advanced knowledge of financial statements and how these are used for firm valuation.
- Capable of understanding and analyzing the financial data for better earning management.
- Capable of making healthy financial decisions and financial forecasting.

Course Outline

Unit 1. Financial Reporting

Summary Annual Report. Generally Accepted Accounting Principles (GAAP). Additional Input: American Institute of Certified Public Accountants. (AICPA). Traditional Assumptions of the Accounting Model. Forms of Business Entities. The Financial Statements. The Accounting Cycle. Auditor's Report

Unit 2. Financial Reporting Analysis

The efficient market hypothesis. Ethics. Harmonization of International Reporting Standards. Consolidated Statements. Accounting for Business Combination

Unit 3. Financial Reporting Analysis

Procedure for the development of the statement of Cash flows. Problems in balance sheet preparation/presentation. Principle, types and instrumentation of electrophoresis. Applications of traditional electrophoresis. Basic elements of the balance sheet. Statement of Stockholder's equity. Basic elements of Income Statement. Special income statement items. Earnings per Share. Retained Earnings. Basic elements of statement of cash flows. Financial ratios and statement of Cash flows. Alternative Cash flows

Unit 4. Basics of Analysis

Ratio Analysis. Common Size Analysis-Vertical and Horizontal Analysis. Year to year change analysis. Financial Statement Variation by type of industry. Review of Descriptive Information. Comparisons. Relative size of firm. The uses of financial statements. Current Assets, Current Liabilities, Operating Cycle. Current Assets compare with Current Liabilities. Other Liquidity

Considerations. Long term debt paying ability. Profitability analysis. Risk analysis.

Unit 5. Investors and Special Industries

Stock options. Leverage and its effect on earnings. Earnings per common share. Price/Earnings Ratio. Percentage of Earnings Retained. Dividend Payout. Book value per share. Banks. Utilities. Oil and Gas. Transportation. Insurance.

Recommended Books/Reference Material

1. Fridson, M. S., & Alvarez, F. (2022). *Financial statement analysis: a practitioner's guide*. John Wiley & Sons.
2. Koop, G. (2022). *Analysis of financial data*. John Wiley & Sons Inc.
3. Palepu, K. G., Healy, P. M., Wright, S., Bradbury, M., & Coulton, J. (2020). *Business analysis and valuation: Using financial statements*. Cengage AU.
4. Robinson, T. R. (2020). *International financial statement analysis*. John Wiley & Sons.
5. Schroeder, R. G., Clark, M. W., & Cathey, J. M. (2022). *Financial accounting theory and analysis: text and cases*. John Wiley & Sons.

Corporate Finance

Course Code: FIN-413

Credit Hours: 03

Pre-requisite: Nil

Objectives

The main aim of this course is to improve the financial decision making in any corporation. If the financial decision taken is not correct, the repercussions may be quite severe and, in many cases, due to the wrong financial decisions, the corporations have even been shut down. Thus, correct financial decision is very important for taking right financial decision, it is very much required that a person is well apprised of all the aspects of corporate finance and this course enables participants to do that. There are many basic issues related to the course e.g. capital budgeting, capital structure, corporate investment, sources of corporate funding, corporate contingent claims, dividend policy, financial risk management etc. Thus, it can be said that all the financial aspects of a corporation are covered in this course. All these aspects enable a person to apply these fundamentals of finance in a right way in the corporation so that the goal of the corporation is easily achieved.

Learning Outcomes

- To make effective use of financial resources available to an organization.
- To evaluate various alternatives available to acquire fixed assets.

- To develop and analyze the pro-forma financial statements and also the sensitivity and scenario analysis for decision making.

Course Outline

Unit 1. Financial Planning and Growth

Financial Planning models. External financing and growth. Internal growth and sustainable growth. Project cash flows. Investment cash flows. Pro forma financial statements. Scenario and other what-if analysis. Operating leverage. Capital ratios.

Unit 2. Raising Capital

Early-stage financing & venture capital, underwriters. IPOs and underpricing Costs of issuing securities. Rights, dilution. Issuing long term debt. Securitization (bundling-unbundling). Mutual funds management. Capital structure and cost of capital. The effect of financial leverage. Optimal capital structure.

Unit 3. Dividends and Dividend Policy

Cash dividend and dividend payment. Low payout and high payout factors. Establishing a dividend policy. Stock repurchases, stock splits. Short term finance and planning. Operating and cash cycle. Alternative financing policies for current assets. Short term borrowing. Cash and liquidity management

Unit 4. Float Management

Cash collection and disbursements. Target cash balance. Credit and inventory. Credit and receivables. Factorization.

Unit 5. Hybrid Financing: Leasing

What is lease, why lease? Financial and operating lease. Valuation financial lease. Leasing versus purchasing decisions.

Recommended Books/Reference Material

1. Brealey, R. A., Myers, S. C., & Marcus, A. J. (2023). *Fundamentals of corporate finance*. McGraw-Hill.
2. Graham, J., Adam, C., & Gunasingham, B. (2020). *Corporate finance*. Cengage AU.
3. Hillier, D., Ross, S., Westerfield, R., Jaffe, J., & Jordan, B. (2021). *EBOOK: Corporate Finance, 4e*. McGraw Hill.
4. Vernimmen, P., Quiry, P., & Le Fur, Y. (2022). *Corporate finance: theory and practice*. John Wiley & Sons.
5. Ross, S. A., Westerfield, R. W., & Jordan, B. D. (2022). *Fundamentals of corporate finance*.

Security Analysis and Portfolio Management

Course Code: FIN-414

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of the course is to study theory and empirical evidence relevant for portfolio management. An emphasis is placed on understanding how an investment professional would allocate funds in a hypothetical portfolio. Emphasis will be put on development of techniques that should be part of the tool kit of those interested in becoming professional investors and/or researchers in finance. The course material is tilted heavily towards equity markets since there are separate courses that cover fixed income markets and derivative securities.

Learning Outcomes

- Understand the operations of financial markets;
- Analyze the various types of assets including equities, fixed income securities, and derivatives; to perform risk analysis.
- Enhance the skills are required for corporate finance, trading, and investment banking positions.

Course Outline

Unit 1. Portfolio Management

Introduction to investment and portfolio management. Types of portfolios. Types of investors. Investment analysis. Investment strategies. Investment process. And performance evaluation. Efficient market hypothesis.

Unit 2. Stock Market Anomalies

What are anomalies? Different types of anomalies. The effect of anomalies on stock markets. Investors' sentiments and related theories. Investors' sentiment and anomalies. The contradictions to the efficient market hypothesis.

Unit 3. Risk and Return

Risk analysis. The relationship of risk and return. The security market line. The measures of risk and return. The weighted average portfolios. Risk and return of individual security. Risk and return of portfolios.

Unit 4. Portfolio Selection and Analysis

Portfolio selection strategies. Quantitative measures for portfolio selection. Portfolio analysis. Quantitative measures for portfolio analysis.

Unit 5. Asset Pricing Models

Capital asset pricing model. Portfolio performance evaluation.

Recommended Books/Reference Material

1. Bacon, Carl R. (2023). *Practical portfolio performance measurement and attribution*. John Wiley & Sons.
2. Graham, B., & Dodd, D. L. F. (2020). *Security Analysis: The Classic 1940 Second Edition*. Echo Point Books & Media, LLC.
3. Kevin, S. (2022). *Security analysis and portfolio management*. PHI Learning Pvt. Ltd.
4. Laopodis, N. T. (2020). *Understanding investments: Theories and strategies*. Routledge.
5. Magni, C. A. (2020). *Investment decisions and the logic of valuation* (Vol. 689). Springer International Publishing.
6. Rustagi, R. P. (2021). *Investment Management Theory and Practice*. Sultan Chand & Sons.

Financial Risk Management

Course Code: FIN-415

Credit Hours: 03

Pre-requisite: Nil

Objectives

Risk is costly. This statement is absolutely agreed by businessmen and professionals, particularly those facing inherent risk in their professional lives. Minimizing the cost of risk to an optimum level unanimously means that we are increasing the value of a firm. However, the cost of risk minimization, albeit its ease to say or learn conceptually is very much difficult to implement, either by self-managed method or by risk-transfer approach. If a business executive decides to manage the cost of risk herself, she has to estimate direct and indirect costs pertaining to the possibly risky events or occurrences. On the other hand, if executive transfers the risk to a third party, she has to load in insurance premium as the compensation for the insurer, comprising administrative fees and the insurer's business return.

Learning Outcomes

- Get a comprehensive perspective on risk management and insurance concepts, tools, and techniques.
- Develop analytical and integrative thinking in understanding and implementing the risk management practices.

- Arouse the sense of business through an experiential approach, especially in the completion of assignments.

Course Outline

Unit 1. Risk Management

Risk analysis. The relationship of risk and return. The security market line. The measures of risk and return. The weighted average portfolios. Risk and return of individual security. Risk and return of portfolios.

Unit 2. Financial Intermediaries

What are financial intermediaries? The role of financial intermediaries. The risk return analysis. Risk hedging strategies.

Unit 3. Types of Risks

Interest rate risk. Market risk. Credit risk. Off-balance sheet risk. Technology and other operational risks. Foreign exchange risks. Sovereign risk. Liquidity risk.

Unit 4. Derivatives

Options, Swaps. Futures. Forwards. Caps. Floors. Collars.

Unit 5. Securitization

The concept of Securitization. How assets are pooled. How they can be re-packaged into interest-bearing securities.

Recommended Books/Reference Material

1. Bąk, S., & Jędynak, P. (2023). *Risk management maturity: A multidimensional model* (p. 112). Taylor & Francis.
2. Chance, D. M., & Brooks, R. (2021). *An introduction to derivatives and risk management*. South-Western, Cengage Learning.
3. Dietz, S. (2021). *Handbook of Financial Risk Management*.
4. Fraser, J. R., Quail, R., & Simkins, B. (Eds.). (2021). *Enterprise risk management: Today's leading research and best practices for tomorrow's executives*. John Wiley & Sons.
5. Gallati, R. R. (2022). *Risk management and capital adequacy*. McGraw-Hill.
6. Hillson, D. (Ed.). (2023). *The Risk Management Handbook: A practical guide to managing the multiple dimensions of risk*. Kogan Page Publishers.
7. Saunders, A., Cornett, M. M., & Erhemjamts, O. (2021). *Financial institutions management: A risk management approach*. McGraw-Hill.

Islamic Banking

Course Code: FIN-416

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is focusing on the basis of Islamic Finance and Islamic Financial Instruments and covers both their theoretical as well as practical domains. In this course, students are trained to deal with some major contracts. They are given an overview of all participatory modes of financing, sale-based modes of financing, Lease based modes of financing, debt creating modes and sub-contracts. Students then learn the design, operational mechanism, management, documentation, contracts, Shariah rulings and issues related to some major contracts, including Murabahah, Musharakah, Diminishing Musharakah, Mudarabah and Ijarah. A resort is also made to the work of classical as well as contemporary jurists for the better and critical understanding of Islamic finance. Moreover; the views of proponent as well as of opponent of Islamic finance are discussed critically.

Learning Outcomes

- Familiar with the basic philosophies and differences of Islamic and conventional financial systems.
- Familiar with the basic and fundamental principles of Islamic finance
- Familiar with the practical applications and usefulness of Islamic financial products

Course Outline

Unit 1. Islamic Economic System

Factor of production in Islam. The objectives of the distribution of wealth in Islam.

Unit 2. Riba

Riba in Quran. Riba in Hadith. The sources of Riba. Types of Riba. Commercial interest and usury. Simple and Compound Interest.

Unit 3. Contracts

Islamic contracts. The difference between conventional and Islamic contracts. Types of contracts in light of Islam.

Unit 4. Sales

Sales and types of sales in light of Islam. Five Khyars. Development of Islamic financing and Islamic banking in Pakistan.

Unit 5. Islamic Modes of Financing

Musharakah. Mudarabah. Diminishing Musharakah. Murabah.
Istasnah. Muswawamah. Ijarah.

Recommended Books/Reference Material

1. Alamad, S. (2020). *Financial and accounting principles in Islamic finance*. Springer International Publishing.
2. Casu, B., Girardone, C., & Molyneux, P. (2022). *Introduction to banking*. Pearson.
3. Hassan, M. K., Rabbani, M. R., & Rashid, M. (Eds.). (2022). *FinTech in Islamic Financial Institutions: Scope, Challenges, and Implications in Islamic Finance*. Springer Nature.
4. Kuforiji, J. O. (2022). *The essentials of Islamic banking, finance, and capital markets*. Rowman & Littlefield.
5. Zubair, H. (2023). *Islamic Banking and Finance*. Taylor & Francis.

Financial Analytics

Course Code: FIN-417

Credit Hours: 03

Pre-requisite:

Objectives

The focus of this course is on application of statistical, econometric, and machine learning techniques to issues in the financial sector. It is designed to help the students in performing formal analysis with financial data like forecasting of returns, risk analysis, asset pricing, market trend analysis, etc. Financial data has certain characteristics which require different kinds of tools of analysis. The course aims at introducing these techniques through the appropriate research problems and will then move on to real life applications of these tools with financial sector data. Before introducing a tool, the need for such analysis will be explained and then actual applications will be demonstrated.

Learning Outcomes

- Identify the basic structure of capital asset markets
- Identify the main investment vehicles and investment strategy categories
- Knowledge about the most popular statistical methods and machine learning techniques with their applications in finance

Course Outline

Unit 1. Introduction to Analytics: Business intelligence, Business Analytics

Managerial spread sheet analysis and modelling. Applications and Challenges in Business analytics, Marketing and Financial analytics; Organization/sources of data, Importance of data quality, dealing with missing or incomplete data, data. Classification, data presentation/summarization, data mining –process.

Unit 2. Predictive Analytics

Simple linear regression. Multiple linear regression. Logistic multinomial regression. Forecasting techniques. Application of predictive analytics in retail, direct marketing, financial services, insurance, supply chain, etc.

Unit 3. Optimization Analytics

Multi-period linear programming models and applications, network models and project planning, integer programming and Its application in capital budgeting, location decisions, etc.; multi-criteria decision-making techniques-goal programming and analytic hierarchy process and applications. Stochastic Analytics – Introduction to stochastic models, Markov models. Renewal theory, Markov decision process and applications in sequential decision making. Performing regression analysis for estimating future movements. Understanding and applying AI models for financial forecasting. Applying statistical checks for comparative assessment. Techniques to be learned: Simple & Multivariate Regression Analysis. Artificial Neural Network for Forecasting

Unit 4. Analytics under Uncertainty

Survival analysis and its applications; Six Sigma as a problem-solving methodology. Classification and regression trees. Lean thinking. Dynamic pricing and revenue management; high dimensional data analysis; Analytics in Finance – discounted cash flows, profitability analysis, asset performance measurement tools, introduction to Insurance loss models. Characterization of Financial Time Series & Understanding Portfolio Formation: Checking distribution & stationary properties of financial data. Delving nonlinear dynamics of financial data. Developing frameworks for portfolio formation and realignment. Techniques to be learned: Tests to check normality (Jarque-Bera & Shapiro-Wilk Test). Tests to check stationary (ADF & PP Test). Estimating Hurst Exponent and Portfolio Formulation

Unit 5. Role of Feature Selection in Financial Data Analysis

Comprehending feature selection algorithm. Improving predictive accuracy by summarizing data in both supervised and unsupervised mode. Techniques to be learned: Feature Selection Modelling in Supervised Mode. Unsupervised Feature Selection using Principal

Component Analysis. Machine learning; Functionalities and applicability of advanced machine learning models. Ensemble and hybrid models. Techniques to be learned: Machine Learning Tools for Classification and regression tasks in the Context of Financial Modelling. Support Vector Machine (SVM) & Random Forest (RF) Granular Computing for Financial Analytics. ARCH models and their utilities. Measuring dynamic association among various financial assets. Clustering techniques. Applications of deep learning.

Recommended Books/Reference Material

1. Backhaus, K., Erichson, B., Gensler, S., Weiber, R., & Weiber, T. (2021). Multivariate analysis. *Springer Books*.
2. Dugard, P., Todman, J., & Staines, H. (2022). *Approaching multivariate analysis: A practical introduction*. Taylor & Francis.
3. FABOZZI, P. P. D. F. J. (2022). *The Basics of Finance*. Wiley Publishing, Inc.
4. Gujarati, D. N. (2022). *Basic econometrics*. Prentice Hall.
5. Revsine, L., Collins, D. W., & Johnson, W. B. (2021). *Financial reporting & analysis*. McGraw-Hill.

Financial Reporting and Analysis

Course Code: FIN-418

Credit Hours: 03

Pre-requisite:

Objectives

The objective of this course is to enable the students understanding the financial statements of businesses in detailed manner. It enables the students to utilize the published financial information of the corporations for analysis purposes. It facilitates the students to develop a thorough understanding and ways to analyze the financial data of different kinds of corporations especially for problem solving and decision-making purposes.

Learning Outcomes

- Having an advanced knowledge of financial statements and how these are used for firm valuation.
- Capable of understanding and analyzing the financial data for better earning management.
- Capable of making healthy financial decisions and financial forecasting.

Course Outline

Unit 1. Financial Reporting

Summary Annual Report. Generally Accepted Accounting Principles (GAAP). Additional Input: American Institute of Certified Public Accountants. (AICPA). Traditional Assumptions of the Accounting Model. Forms of Business Entities. The Financial Statements. The Accounting Cycle. Auditor's Report

Unit 2. Financial Reporting Analysis

The efficient market hypothesis. Ethics. Harmonization of International Reporting Standards. Consolidated Statements. Accounting for Business Combination

Unit 3. Financial Reporting Analysis

Procedure for the development of the statement of Cash flows. Problems in balance sheet preparation/presentation. Principle, types and instrumentation of electrophoresis. Applications of traditional electrophoresis. Basic elements of the balance sheet. Statement of Stockholder's equity. Basic elements of Income Statement. Special income statement items. Earnings per Share. Retained Earnings. Basic elements of statement of cash flows. Financial ratios and statement of Cash flows. Alternative Cash flows

Unit 4. Basics of Analysis

Ratio Analysis. Common Size Analysis-Vertical and Horizontal Analysis. Year to year change analysis. Financial Statement Variation by type of industry. Review of Descriptive Information. Comparisons. Relative size of firm. The uses of financial statements. Current Assets, Current Liabilities, Operating Cycle. Current Assets compare with Current Liabilities. Other Liquidity Considerations. Long term debt paying ability. Profitability analysis. Risk analysis.

Unit 5. Investors and Special Industries

Stock options. Leverage and its effect on earnings. Earnings per common share. Price/Earnings Ratio. Percentage of Earnings Retained. Dividend Payout. Book value per share. Banks. Utilities. Oil and Gas. Transportation. Insurance.

Recommended Books/Reference Material

1. Fridson, M. S., & Alvarez, F. (2022). *Financial statement analysis: a practitioner's guide*. John Wiley & Sons
2. Gibson, H.C, Financial Reporting & Analysis, South-Western College Publishing (2023).
3. Kimmel, P. D., Weygandt, J. J., & Kieso, D. E. (2020). *Financial accounting: tools for business decision-making*. John Wiley & Sons.

4. Palepu, K. G., Healy, P. M., Wright, S., Bradbury, M., & Coulton, J. (2020). *Business analysis and valuation: Using financial statements*. Cengage AU.
5. Revsine, L., Collins, D. W., & Johnson, W. B. (2021). *Financial reporting & analysis*. McGraw-Hill.
6. Solomons, D. (2021). *Guidelines for financial reporting standards*. Routledge.
7. Stinckney, C.P. Financial Reporting and Statement Analysis, A Strategic Perspective, The Drydan Press. (2023).