SCHEME OF STUDIES

Associate Degree in Mathematics (For Affiliated Colleges)

(2023)

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF SARGODHA
SARGODHA

Scheme of Studies

Associate Degree in Mathematics
(For Affiliated Colleges)

Semester-I

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
GE-1	URCG-5118	Functional English	3(3-0)	Nil
GE-2	URCG-5105 URCG-5126	Islamic Studies (OR) Religious Education/Ethics	2(2-0)	Nil
GE-3	URCG-5123	Applications of Information and Communication Technologies (ICT)	3(2-1)	Nil
Major-1	MATH-5101	Calculus-I	3(3-0)	Nil
Major-2	MATH-5102	Set Theory and Mathematical Logic	3(3-0)	Nil
Major-3	MATH-5103	Vector and Tensor Analysis	3(3-0)	Nil
GE-4	URCG-5111	Translation of Holy Quran-I*	Non-Cr. Hour	Nil

Semester Total Credit Hours: 17

Semester-II

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
GE-5	URCG-5112	Fables, Wisdom and EPICS	2(2-0)	Nil
GE-6	URCG-5116	Science of Society-I	2(2-0)	Nil
GE-7	URCG-5120	Exploring Quantitative Skills	3(3-0)	Nil
GE-8	URCG-5127	Seerat of the Holy Prophet (SAW)*	1(1-0)	Nil
Major-4	MATH-5104	Calculus-II	3(3-0)	MATH-5101
Major-5	MATH-5105	Linear Algebra	3(3-0)	Nil
Major-6	MATH-5106	Mechanics	3(3-0)	Nil

Semester Total Credit Hours: 17

Semester-III

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
GE-9	URCG-5119	Expository Writing	3(3-0)	Nil
GE-10	URCG-5121	Tools for Quantitative Reasoning	3(3-0)	Nil
GE-11	URCG-5122	Ideology and Constitution of Pakistan	2(2-0)	Nil
Major-7	MATH-5107	Calculus-III	3(3-0)	MATH-5104
Major-8	MATH-5108	Algebra-I	3(3-0)	Nil
Major-9	MATH-5109	Ordinary Differential Equations	3(3-0)	Nil
GE-4	URCG-5111	Translation of Holy Quran-II*	Non-Cr. Hour	Nil

Semester Total Credit Hours: 17

Semester-IV

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
GE-12	URCG-5114	Basic Science	3(2-1)	Nil
GE-13	URCG-5124	Entrepreneurship	2(2-0)	Nil
GE-14	URCG-5125	Civics and Community Engagement	2(2-0)	Nil
Major-10	MATH-5110	Algebra-II	3(3-0)	MATH-5108
Major-11	MATH-5111	Discrete Mathematics	3(3-0)	Nil
Major-12	MATH-5112	Number Theory	3(3-0)	Nil

Semester Total Credit Hours: 16

Total Credit Hours: 67

*These courses for Muslim students only.

MATH-5101 **Calculus-I** **3 (3-0)**

Calculus is the mathematical study of continuous change. If quantities are continually changing, we need calculus to study what is going on. Calculus is concerned with comparing quantities which vary in a non-linear way. It is used extensively in science & engineering, since many of the things we are studying (like velocity, acceleration, current in a circuit) do not behave in a simple, linear fashion. Calculus has two major branches, differential calculus (Calculus-I) & integral calculus (Calculus-II); the former concerns instantaneous rates of change, & the slopes of curves, while integral calculus concerns accumulation of quantities, & areas under or between curves. This is the first course of the sequence, Calculus-I, II & III, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts & skills needed for mathematical manipulation. It focuses on the study of functions of a single variable. Calculus-I is an introduction to differential & integral calculus: the study of change.

Contents

1 Functions & their graphs, Rates of change & tangents to curves
2 Limit of a function & limit laws, the precise definition of a limit
3 One-sided limits, continuity, Limits involving infinity; asymptotes of graphs
4 Differentiation: tangents & derivative at a point, the derivative as a function
5 Differentiation rules, the derivative as a rate of change
6 Derivatives of trigonometric functions, Chain rule, implicit differentiation
7 Related rates, linearization & differentials, higher derivatives
8 Applications of derivatives: extreme values of functions
9 Rolls' theorem, the mean value theorem, Monotonic functions & the first derivative test
10 Convexity, point of inflection & second derivative test, Concavity & curve sketching
11 Applied optimization, Antiderivatives, integration: area & estimating with finite sums
12 Sigma notation & limits of finite sums, definite integral, the fundamental theorem of calculus
13 Indefinite integrals & the substitution method, Substitution & area between curves
14 Applications of definite integrals: volumes using cross-sections
15 Volumes using cylindrical shells, arc length, Areas of surfaces of revolution
16 Transcendental functions: inverse functions & their derivatives
17 Natural logarithms, exponential functions, Indeterminate forms & L'Hôpital's rule
18 Inverse trigonometric functions, hyperbolic functions

Recommended Texts

1. Thomas, G.B., Weir, M. D.,& Hass J. R. (2014).*Thomas' calculus: single variable*(13th ed./Latest). London: Pearson.
2. Stewart, J. (2015).*Calculus* (8th ed. /Latest). Boston: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C.,& Davis, S. (2016).*Calculus* (11th ed. /Latest). New York: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I.,& Asmar, N. H. (2017).*Calculus & its applications*(14th ed.). London: Pearson.
3. Larson, R.,& Edwards, B. H. (2013).*Calculus* (10th ed. /Latest).New York: Brooks Cole.

MATH-5102 **Set Theory and Mathematical Logic** **3 (3-0)**

The main aim of this course is the study of set theory & the concept of mathematical logic. Everything mathematicians do can be reduced to statements about sets, equality & membership which are basics of set theory. This course introduces these basic concepts. The foundational role of set theory & its mathematical development has raised many philosophical questions that have been debated since its inception in the late nineteenth century. The course begins with propositional logic, including two-column proofs and truth table applications, followed by first-order logic, which provides the structure for writing mathematical proofs. Set theory is then introduced and serves as the basis for defining relations, functions, numbers, mathematical induction, ordinals, and cardinals. In particular, mathematicians have shown that virtually all mathematical concepts & results can be formalized within the theory of sets. The course aims at familiarizing the students with cardinals, ordinal numbers, relations, functions, Boolean algebra, fundamentals of propositional & predicate logics.

Contents

1 Set theory: sets, subsets
2 Operations with sets: union, intersection, difference, symmetric difference
3 Cartesian product & disjoint union
4 Functions: graph of a function
5 Composition; injections, surjections, bijections, inverse function
6 Computing cardinals: Cardinality of Cartesian product, union
7 Cardinality of all functions from a set to another set
8 Cardinality of all injective, surjective & bijective functions from a set to another set
9 Infinite sets, finite sets, Countable sets, properties & examples
10 Operations with cardinal numbers. Cantor-Bernstein theorem
11 Relations: equivalence relations
12 Partitions, quotient set; examples
13 Parallelism, similarity of triangles
14 Order relations, min, max, inf, sup; linear order
15 Examples: N, Z, R, P(A). Well ordered sets & induction
16 Inductively ordered sets & Zorn's lemma
17 Mathematical logic: propositional calculus. truth tables
18 Predicate calculus

Recommended Texts

1. Halmos, P. R. (2019). *Native set theory*. New York: Bow Wow Press.
2. Lipschuts, S. (1998). *Schaum's outline of set theory & related topics* (2nd ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Pinter, C. C. (2014). *A book of set theory*. New York: Dover Publication.
2. O'Leary, M. L. (2015). *A first course in mathematical logic & set theory* (1st ed.). New York: Wiley.
3. Smith, D., Eggen, M.,&Andre, R.S. (2014). *A transition to advanced mathematics* (8th ed.). New York: Brooks/Cole.

MATH-5103 ` Vector & Tensor Analysis 3 (3-0)

This course is designed primarily for those students taking courses in mathematics. Vector and tensor algebra have in recent years become basic part of fundamental mathematical background required of those in engineering, sciences and allied disciplines. It is said that vector and tensor analysis is a natural aid in forming mental pictures of physical and geometrical ideas. A most rewarding language and mode of thought for the physical sciences. The focus, therefore, is to impart useful skills on the students in order to enhance their Mathematical ability in applying vector technique to solve problems in applied sciences and to equip them with necessary skill required to cope with higher levels courses in related subjects. Topics to be covered in this course include, basic vector 2 algebra, coordinate bases, gradient, divergence, and curl, Green's, Gauss' and Stokes' theorems. The metric tensor, Christoffel symbols and Riemann curvature tensor. Applications will be drawn from differential geometry, continuum mechanics, electromagnetism, general relativity theory.

Contents

1 Vector Analysis: Scalar triple product with applications
2 Vector triple product with applications
3 Gradient of a scalar function
4 Divergence of vector functions
5 Curl of vector functions
6 Application of the del operator
7 Curvilinear coordinates
8 Coordinates surfaces
9 Cartesian Tensors: Summation convention
10 Transformation equations
11 Orthogonally conditions
12 Kronecker delta & Levi-civita symbol
13 Tensors of different ranks
14 Symmetric & anti symmetric tensors
15 Related theorems
16 Application to Vector Analysis

Recommended Texts

1. Shah, N.A. (2015). *Vector & tenser analysis*. Lahore: Ilmi Ketab Khana.
2. Spiegel, M.R. (2016). *Vector & Introduction to tensor analysis.* New York: McGraw Hill.
3. Yousuf, S.M. (1988). *Elementary Vector analysis*. Lahore: Ilmi Ketab Khana.

Suggested Readings

1. Young, E.C. (1993). *Vector & tensor analysis*. New York: Marcel Dekker, Inc.
2. Brand, L. (2006). *Vector analysis*, New York: Dover Publications.

MATH-5104 **Calculus-II** **3(3-0)**

This is the second course of the basic sequence Calculus serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts & skills needed for mathematical manipulation. As continuation of Calculus-I, it focuses on the study of functions of a single variable. This Core Curriculum course is designed to meet the following four learning goals: Students will construct and evaluate logical arguments. Students will apply and adapt a variety of appropriate strategies to solve mathematical problems. Students will recognize and apply mathematics in contexts outside of mathematics. Students will organize and consolidate mathematical thinking through written and oral communication. Students will integrate transcendental functions, including logarithms, exponential, trigonometry and inverse trigonometric, hyperbolic and inverse hyperbolic functions, apply methods of integration, such as algebraic substitution, trigonometric substitution, partial fractions, integration by parts, and use a table of integrals, solve limit problems involving indeterminate forms with La'Hopital's Rule and convert parametric representation of curves to rectangular coordinates, represent a curve using polar coordinates, and integrate functions expressed in polar coordinates.

Contents

1 Techniques of integration: Using Basic Integration Formulas, Integration by Parts
2 Trigonometric Integrals, Trigonometric Substitutions
3 Integration of Rational Functions by Partial Fractions
4 Integral Tables & Computer Algebra Systems, Numerical Integration, Improper Integrals
5 Sequences & Infinite Series, The Integral Test, Comparison Tests
6 Absolute Convergence, The Ratio & Root Tests
7 Alternating Series & Conditional Convergence
8 Power Series, Taylor & Maclaurin Series, Convergence of Taylor Series
9 The Binomial Series & Applications of Taylor Series
10 Parametrizations of Plane Curves
11 Calculus with Parametric Curves, Polar Coordinates
12 Graphing Polar Coordinate Equations
13 Areas & Lengths in Polar Coordinates, Conic Sections, Conics in Polar Coordinates

Pre-requisite: Calculus-I

Recommended Texts

1 Thomas, G. B., Weir, M. D.,& Hass, J. R. (2014). *Thomas' calculus: single variable* (13th ed. /Latest).London: Pearson.
2 Stewart, J. (2012). *Calculus*, (8th ed. /Latest). New York: Cengage Learning.

Suggested Readings

1 Anton, H., Bivens, I. C.,& Davis, S. (2016). *Calculus*, (11th ed. /Latest). New York: Wiley.
2 Goldstein, L. J., Lay, D. C., Schneider, D. I., & Asmar, N. H. (2017). *Calculus &its applications* (14th ed.). London: Pearson.
3 Larson, R., & Edwards, B. H. (2013). *Calculus* (10th ed. /Latest). New York: Brooks Cole.

MATH-5105 **Linear Algebra** **3(3-0)**

Linear algebra is the study of linear systems of equations, vector spaces, and linear transformations. Solving systems of linear equations is a basic tool of many mathematical procedures used for solving problems in science and engineering. Linear Algebra plays a significant role in many areas of mathematics, statistics, engineering, the natural sciences, and the computer sciences. It provides a foundation of important mathematical ideas that will help students be successful in future coursework. The main objective of this course is to help students to learn in rigorous manner, the tools & methods essential for studying the solution spaces of problems in mathematics and in other fields& develop mathematical skills needed to apply these to the problems arising within their field of study and to various real-world problems. The student will become competent in solving linear equations, performing matrix algebra, calculating determinants, finding eigenvalues & eigenvectors and the student will come to understand a matrix as a linear transformation relative to a basis of a vector space.

Contents

1 Representation of linear equations in matrix form
2 Solution of linear system, Gauss-Jordan & Gaussian elimination method
3 Vector space, definition, examples & properties
4 Subspaces, Linear combination & spanning set
5 Linearly Dependent & Linearly Independent sets
6 Bases & dimension of a vector space
7 Intersections, sums & direct sums of subspaces, Quotient Spaces, Change of basis
8 Linear transformation, Rank & Nullity of linear transformation
9 Matrix of linear transformations
10 Eigen values & eigen vectors, Dual spaces
11 Inner product Spaces with properties, Projection
12 Cauchy inequality
13 Orthogonal & orthonormal basis
14 Gram Schmidt process & diagonalization

Recommended Texts

1. Dar, K.H. (2007). *Linear algebra* (1st ed.). Karachi: The Carwan Book House.
2. Kolman, B.,& Hill, D. R. (2005). *Introductory linear algebra* (8th ed.). London: Pearson/Prentice Hall.

Suggested Readings

1. Cherney, D., Denton, T., Thomas, R.,& Waldron, A. (2013). *Linear algebra* (1st ed.). California: Davis.
2. Anton, H., & Rorres, C. (2014). *Elementary linear algebra: applications version* (11th ed.). New York: John Wiley & Sons.
3. Grossman, S. I. (2004). *Elementary linear algebra* (5th ed.). New York: Cengage Learning.

MATH-5106 **Mechanics** **3(3-0)**

This course shall assume background in calculus. This course introduces the fundamental principles in mechanics. Structural design applications of a variety of problems are developed throughout the course using examples that elucidate the theory of mechanics. It emphasizes on the laws of friction, equilibrium, center of gravity & harmonic & orbital motion. The objectives of the course are to develop better understanding of key concepts concerning scalar and vector fields learned previously in Multivariable Calculus courses, to gain deeper knowledge of multivariate differentiation operations such as Gradient, Divergent and Curl, master the Integral Theorems at the core of Vector Analysis: the Stokes (Greens') Theorem and the Divergence (Gauss') Theorem and to learn the utility of Vector Analysis by learning its relevance to Maxwell's equations describing the dynamics of electric and magnetic fields. In this course, students are prepared for further study in the relevant technological disciplines and more advanced mathematics courses.

Contents

1 Mechanics: Composition & resolution of co-planar forces, Moments
2 Couples & conditions of equilibrium under the action of co-planar forces
3 Frictional forces, Laws of friction
4 Equilibrium of bodies on rough surfaces
5 Principle of virtual work & related problems
6 Center of gravity, Center of mass of various bodies
7 Kinematics of a particle in Cartesian & polar co-ordinates
8 Linear & angular velocity
9 Rectilinear motion with uniform & variable acceleration
10 Simple harmonic motion
11 Projectile motion
12 Motion along horizontal & vertical circles

Recommended Texts

1. Munawar, H., Saeed, S.M., & Ahmed, C.B. (2016). *Elementary vector analysis.* Lahore:The Caravan Book House.
2. Ghori, Q.K. (2015). *Mechanics.* Lahore: West Pakistan Publishing Company.

Suggested Readings

1. Spiegel, M. R., Lipschutz, S.,& Spellman, D. (2009). *Schaum's outline vector analysis* (2nd ed.). New York: McGraw-Hill Education.
2. Brand, L. (2006). *Vector analysis.*New York: Dover Publications.
3. Yousuf, S.M. (1988). *Vector analysis*. Lahore: Ilmi Ketab Khana.

MATH-5107 **Calculus-III** **3(3-0)**

This is the third course of the basic sequence Calculus-1, II & III, serving as the foundation of advanced subjects in all areas of mathematics. It focuses on the study of functions of a multivariable. The main focus of the course is to the study of multiple integrals in different coordinate systems & their applications. Moreover, a brief introduction to vector calculus will also be presented.

Contents

1 Vectors & analytic geometry in space: Three-dimensional Coordinate System
2 Vectors, lines & planes in space
3 The dot product, the cross product
4 Cylinder & Quadric surfaces, vector-valued functions
5 Vector functions & space curve
6 Derivatives & integrals of vector functions
7 Arc length & Curvature
8 Motion in space, Velocity & Acceleration
9 Tangential & Normal Components of Acceleration
10 Velocity & Acceleration in Polar Coordinates
11 Functions of several variables, limits, Continuity & partial derivatives
12 Chain rule, directional derivatives & the gradient vector
13 Maximum & minimum values, optimization problems, Lagrange Multipliers
14 Multiple integrals: Double integrals over rectangles & iterated integrals
15 Double integrals over general regions
16 Double integrals in polar coordinates
17 Triple integrals in rectangular, cylindrical & spherical coordinates
18 Applications of double & triple integrals, Change of variables in multiple integrals
19 Vector calculus**:** Vector fields, line integrals, The fundamental theorem of Line Integrals
20 Green's theorem, Curl & divergence
21 Surface integrals over scalar & vector fields
22 Divergence theorem, Stokes' theorem

Pre-requisite: Calculus-II

Recommended Texts

1. Thomas, G. B., Weir, M.D.,& Hass J.R. (2014). *Thomas' Calculus: multivariable* (13th ed. /Latest).London: Pearson.
2. Stewart, J. (2015). *Calculus* (8th ed. /Latest). New York: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens, I. C.,& Davis, S. (2016). *Calculus* (11th ed. /Latest). New York: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I.,& Asmar, N. H. (2017). *Calculus & its applications* (14th ed. /Latest). London: Pearson.
3. Larson, R.,& Edwards, B. H. (2013). *Calculus* (10th ed. /Latest). New York: Brooks Cole.

MATH-5108 **Algebra-I** **3(3-0)**

This course is an introduction to group theory, one of the three main branches of pure mathematics. Group theory is the study of groups. Group theory is one of the great simplifying and unifying ideas in modern mathematics. It was introduced in order to understand the solutions to polynomial equations, but only in the last one hundred years has its full significance, as a mathematical formulation of symmetry, been understood. It plays a role in our understanding of fundamental particles, the structure of crystal lattices and the geometry of molecules. In this course, we will begin by defining the axioms satisfied by groups and begin to develop basic group theory by reference to some elementary examples. We will analyse the structure of 'small' finite groups, and examine examples arising as groups of permutations of a set, symmetries of regular polygons and regular solids, and groups of matrices. We will develop the notions of homomorphism, normal subgroups and quotient groups and study the First Isomorphism Theorem and its application.

Contents

1 Groups, definition & examples of groups, elementary properties of groups
2 Finite & Infinite Groups
3 Order of element of a group & related results
4 Subgroups, examples of subgroup, subgroup tests, subgroup generated by set
5 Cyclic groups, properties of cyclic groups
6 Classification of subgroups of cyclic groups
7 Cosets decomposition of a group, properties of cosets
8 Lagrange's theorem & its consequences
9 Conjugate elements & conjugacy classes
10 Centralizer of a subset of a group, normalizer of a subset of a group
11 Center of group definition & examples
12 Normal Subgroups, factor groups, application of factor groups
13 Permutations & Permutation groups, definition & examples
14 Homomorphism of groups, properties of Homomorphisms
15 Fundamental theorem of homomorphism
16 Isomorphism theorems, properties of Isomorphisms & Cayley's theorem
17 Endomorphism & automorphisms of groups, Commutator subgroups
18 External & Internal direct products, definition & examples

Recommended Texts

1. Gallian, J.A. (2017). *Contemporary abstract algebra* (9th ed.). New York: Brooks/Cole.
2. Malik, D. S., Mordeson, J. N.,& Sen, M.K. (1997). *Fundamentals of abstract algebra*. New York: WCB/McGraw-Hill.

Suggested Readings

1. Roman, S. (2012). *Fundamentals of group theory* (1st ed.). Basel: Birkhäuser.
2. Rose, H. E. (2006). *A course on finite groups* (1st ed.). London: Springer-Verlag.
3. Fraleigh, J.B. (2003). A*first course in abstract algebra*(7th ed.).Boston: Addison-Wesley Publishing Company.

MATH-5109 Ordinary Differential Equations 3(3-0)

This course introduces the theory, solution, & application of ordinary differential equations. Topics discussed in the course include methods of solving first-order differential equations, existence & uniqueness theorems, second-order linear equations, power series solutions, higher-order linear equations, systems of equations, non-linear equations, Sturm-Liouville theory, & applications. The relationship between differential equations & linear algebra is emphasized in this course. An introduction to numerical solutions is also provided. Applications of differential equations in physics, engineering, biology, & economics are presented. The goal of this course is to provide the student with an understanding of the solutions & applications of ordinary differential equations. The course serves as an introduction to both nonlinear differential equations & provides a prerequisite for further study in those areas.

Contents

1 Introduction to differential equations: Preliminaries & classification of differential equations
2 Verification of solution, existence of unique solutions, introduction to initial value problems
3 Basic concepts, formation & solution of first order ordinary differential equations
4 Separable equations, linear equations, integrating factors, Exact Equations
5 Solution of nonlinear first order differential equations by substitution, Homogeneous Equations,
6 Bernoulli equation, Ricaati's equation & Clairaut equation
7 Modeling with first-order ODEs: Linear models, Nonlinear models
8 Higher order differential equations: Initial value & boundary value problems
9 Homogeneous & non-homogeneous linear higher order ODEs & their solutions, Wronskian,
10 Reduction of order, homogeneous equations with constant coefficients,
11 Nonhomogeneous equations, undetermined coefficients method, Superposition principle
12 Annihilator approach, variation of parameters, Cauchy-Euler equation,
13 Solving system of linear differential equations by elimination
14 Solution of nonlinear differential equations
15 Power series, ordinary & singular points & their types, existence of power series solutions
16 Frobenius theorem, existence of Frobenius series solutions
17 The Bessel, Modified Bessel, Legendre & Hermite equations & their solutions
18 Sturm-Liouville problems: Introduction to eigen value problem, adjoint & self-adjoint operators,
19 Self-adjoint differential equations, eigen values & eigen functions
20 Sturm-Liouville (S-L) boundary value problems, regular & singular S-L problems

Recommended Texts

1 Boyce, W. E., & Diprima, R. C. (2012). *Elementary differential equations & boundary value problems* (10^{th} ed.) USA: John Wiley & Sons.
2 Zill, D.G., & Michael, R. (2009) *Differential equations with boundary-value problems* (5^{th} ed.) New York: Brooks/Cole.

Suggested Readings

1 Arnold, V. I. (1991). *Ordinary differential equations* (3^{rd} ed.). New York: Springer.
2 Apostol, T. (1969). *Multi variable calculus &linear algebra* (2^{nd} ed.). New York: John Wiley & sons.

MATH-5110 **Algebra-II** **3(3-0)**

This course is continuation of the course series of Algebra, which builds on the concepts learnt in Algebra-I. This course is an introduction to ring theory. The philosophy of this subject is that we focus on similarities in arithmetic structure between sets (of numbers, matrices, functions or polynomials for example) which might look initially quite different but are connected by the property of being equipped with operations of addition and multiplication. Much of the activity that led to the modern formulation of ring theory took place in the first half of the 20th century. Ring theory is powerful in terms of its scope and generality, but it can be simply described as the study of systems in which addition and multiplication are possible. The objectives of the course are to introduce students to the basic ideas & methods of modern algebra & enable them to understand the idea of a ring & an integral domain, & be aware of examples of these structures in mathematics; appreciate & be able to prove the basic results of ring theory; The topics covered include ideals, quotient rings, ring homomorphism, the Euclidean algorithm & the principal ideal domains.

Contents

1 Rings: Definition, examples. Quadratic integer rings
2 Examples of non-commutative rings
3 The Hamilton quaternions
4 Polynomial rings
5 Matrix rings. Units, zero-divisors
6 Nilpotents, idempotents. Subrings, Ideals
7 Maximal & prime Ideals. Left, right & two-sided ideals; Operations with ideals
8 The ideal generated by a set. Quotient rings. Ring homomorphism
9 The isomorphism theorems, applications
10 Finitely generated ideals
11 Rings of fractions
12 Integral Domain: The Chinese remainder theorem. Divisibility in integral domains
13 Greatest common divisor, least common multiple
14 Euclidean domains, the Euclidean algorithm, Principal ideal domains
15 Prime & irreducible elements in an integral domain
16 Gauss lemma, irreducibility criteria for polynomials

Pre-requisite: Algebra-I

Recommended Texts

1. Gallian, J. A. (2017). *Contemporary Abstract algebra* (9th ed.) New York: Brooks/Cole.
2. Malik D. S., & Mordeson J. N., & Sen M. K. (1997). *Fundamentals of abstract algebra* (1st ed.). New York: WCB/McGraw-Hill.

Suggested Readings

1. Roman, S. (2012). *Fundamentals of group theory* (1st ed.). Switzerland: Birkhäuser Basel.
2. Rose, J. (2012). *A course on group theory*. New York: Dover Publications.
3. Fraleigh, J. B. (2003). A *first course in abstract algebra* (7th ed.). New York: Pearson.

MATH-5111 **Discrete Mathematics** **3(3+0)**

This is an introductory course in discrete mathematics. Discrete Mathematics is study of distinct, un-related topics of mathematics; it embraces topics from early stages of mathematical development & recent additions to the discipline as well. It is the study of mathematical structures that are fundamentally discrete rather than continuous. In contrast to real numbers that have the property of varying "smoothly", the objects studied in discrete mathematics, such as integers, graphs, & statements in logic. The goal of this course is to introduce students to ideas and techniques from discrete mathematics that are widely used in science and engineering. This course teaches the students techniques in how to think logically and mathematically and apply these techniques in solving problems. To achieve this goal, students will learn logic and proof, sets, functions, as well as algorithms and mathematical reasoning. Key topics involving relations, graphs, trees, and formal languages and computability are covered in this course. The present course restricts only to counting methods, relations & graphs. The objective of the course is to inculcate in the students the skills that are necessary for decision making in non-continuous situations.

Contents

1 Counting methods: Basic methods: product
2 inclusion-exclusion formulae
3 Permutations & combinations
4 Recurrence relations & their solutions
5 Generating functions
6 Double counting & its pplications
7 Pigeonhole principle & its applications
8 Relations: Binary relations, n-ary Relations, closures of relations
9 Composition of relations, inverse relation
10 Graphs: Graph terminology
11 Representation of graphs
12 Graphs isomorphism
13 Algebraic methods: the incidence matrix, connectivity
14 Eulerian & Hamiltonian paths, shortest path problem
15 Trees & spanning trees, Complete graphs & bivalent graphs

Recommended Texts

1. Rosen, K.H. (2012). *Discrete mathematics & its applications.* New York: The McGraw-Hill Companies, Inc.
2. Chartr, G., & Zhang, P. (2012). *A first course in graph theory.* New York: Dover Publications, Inc.

Suggested Readings

1. Tucker, A. (2002). *Applied combinatorics.* New York: John Wiley & Sons.
2. Diestel, R. (2010). *Graph theory* (4th ed.). New York: Springer- Verlag
3. Brigs, N. L. (2003). *Discrete mathematics.* Oxford: Oxford University Press.

MATH-5112 **Number Theory** **3(3-0)**

Number theory (or arithmetic or higher arithmetic in older usage) is a branch of pure mathematics devoted primarily to the study of the integers & integer-valued functions. Integers can be considered either in themselves or as solutions to equations (Diophantine geometry). There are two subfields of number theory. One is Analytical Number Theory and other is Algebraic number theory. The focus of the course is on study of the fundamental properties of integers & develops ability to prove basic theorems. The specific objectives include study of division algorithm, prime numbers & their distributions, Diophantine equations & the theory of congruences. Students will learn about the arithmetic of algebraic number fields. They will learn to prove theorems about integral bases, & about unique factorization into ideals. They will learn to calculate class numbers, & to use the theory to solve simple Diophantine equations.

Contents

1 Divisibility
2 Euclid's theorem
3 Congruences, Elementary properties
4 Residue classes & Euler's function
5 Linear congruence & congruence of higher degree
6 Congruences with prime moduli
7 The theorems of Fermat
8 Euler & Wilson theorem
9 Primitive roots & indices
10 Integers belonging to a given exponent
11 Composite moduli Indices
12 Quadratic Residues
13 Composite moduli
14 Legendre symbol
15 Law of quadratic reciprocity, The Jacobi symbol
16 Number-Theoretic Functions
17 Mobius function
18 The function [x]
19 Diophantine Equations
20 Equations & Fermat's conjecture for n = 2, n = 4

Recommended Texts

1. Rosen, K.H. (2000). *Elementary number theory & its applications*. (4th ed.). Boston: Addison-Wesley.
2. Apostal, T.M. (2010). *Introduction to analytic number theory* (3rd ed.). New York: Springer.

Suggested Readings

1. Leveque, W.J. (2002). *Topics in number theory*, Volumes I & II. New York: Dover Books.
2. Burton, D.M. (2007). *Elementary number theory*. New York: McGraw-Hill.