# ST ALOYSIUS COLLEGE (AUTONOMOUS)
# MANGALURU

Re-accredited by NAAC "A" Grade

## Course structure and syllabus of

OF

# M.Sc.
# MATHEMATICS

CHOICE BASED CREDIT SYSTEM (CBCS)

(2021 –22 BATCH ONWARDS)

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Re-accredited by NAAC with 'A' Grade with CGPA 3.62/4
Recognised by UGC as "College with Potential for Excellence"
Conferred "College with "STAR STATUS" by DBT, Government of India.
Centre for Research Capacity Building under UGC-STRIDE

Date: 16-02-2021

## NOTIFICATION

Sub: Syllabus of **M.Sc. Mathematics** under Choice Based Credit System.

Ref: 1. Decision of the Academic Council meeting held on 12-12-2020 vide Agenda No: 10(2021-22)

2. Office Notification dated 16-02-2021

Pursuant to the above, the Syllabus of **M.Sc. Mathematics** under Choice Based Credit System which was approved by the Academic Council at its meeting held on 12-12-2020 is hereby notified for implementation with effect from the academic year **2021-22**.

PRINCIPAL

ST. ALOYSIUS COLLEGE MANGALURU 575 003 (AUTONOMOUS)

REGISTRAR

To:

1. The Chairman/Dean/HOD.
2. The Registrar Office
3. Library
4. PG Office

Head of the Dept. of P. G. Mathematics St Aloysius College Autonomous Mangaluru-575003

# M.Sc. MATHEMATICS

**PREAMBLE:**

St Aloysius College established in 1880 as a minority institution is managed by the Jesuit Fathers of Mangalore Educational Society (MJES). The college was conferred autonomy from the academic year 2007-08. The Department of Mathematics, a pioneer in Mathematics education in the district, with some of the illustrious teachers of the past and the present, aims at building brains in pure science. Also the goal is building total personality of the student transforming young boys and girls into men and women for others, having compassion concern and commitment to the society. The proposed M.Sc. Course in Mathematics is an added commitment of the institution to the cause of higher education with an aim of serving the community. Though the basic structure of the Mangalore University syllabus has been maintained, new and modern papers and topics have been introduced, and structural changes are incorporated to suit the credit system under autonomy.

**OBJECTIVES:**

- To provide knowledge and skills in its applications in the field of mathematics
- To generate manpower trained in mathematics to meet the need of industry and the academia.
- To train students to pursue research in the field of pure and applied mathematics.
- To impart training in mathematics to apply it to the computers and IT.
- To develop the personality of an individual by giving them the necessary skills.
- To offer 100% placement assistance.

## PROGRAMME OUTCOMES:

On completion of 2 years M.Sc. Mathematics programme, student will be able to

**PO1** Understand the fundamental axioms in Mathematics and develop problem solving skills.

**PO2** Develop analytical thinking and logical reasoning.

**PO3** Pursue careers in academia, industry and the other areas of Mathematics.

**PO4** Apply knowledge of Mathematics in all fields of learning including higher research and its extensions.

**PO5** Crack lectureship and fellowship exams approved by UGC like CSIR-NET, KSET, GATE etc.

## PROGRAMME SPECIFIC OUTCOMES:

On completion of 2 years M.Sc Mathematics programme, student will be able to

**PSO1** Understand formal mathematical definitions, concepts and apply them to prove statements in Analysis

**PSO2** Develop problem solving skills using Matrix Theory in Linear Algebra and will be able to apply in other fields.

**PSO3** Understand the concepts of groups, rings, fields and other algebraic structures.

**PSO4** Understand the importance and applications of Operations Research to find solutions to real life problems.

**PSO5** Understand various properties of topological spaces and be able to prove Lindelof's theorem, Urysohn's Lemma, Tietze Extension theorem, etc.

**PSO6** Understand the concept of Graphs and its wide range of applications in physical, biological, social and information systems

**PSO7** Learn techniques of Complex Analysis, describe domains and compute limits in the complex plane, use the Cauchy-Riemann equations to obtain the derivative of complex functions, evaluate integrals using Residue theorem.

**PSO8** Apply the fundamental concepts of Numerical Analysis, Ordinary Differential Equations and Partial Differential Equations

**PSO9** Understand the fundamental applications of Functional Analysis and the concepts associated with the dual of a linear space.

**PSO10** To solve problems using FOSS and prepare documents using Latex software which will be very useful for their research programs

### SCOPE OF THE COURSE:

M.Sc. in Mathematics is a post graduate course with job opportunities in academia and industry.

The Research and Development section of every industry requires personnel who are trained in data analysis. There is great need of personnel in teaching profession and in pure research. The course structure and curriculum is designed to enable the students to develop analytical and creative abilities which are very much needed in every field. The Course is definitely at par if not less with many of the famous institutes who offer a post graduate degree in Mathematics

## COURSE PATTERN:

The M.Sc. Mathematics Programme shall comprise "Core" and "Open Elective" Courses. The "Core" courses shall further consist of "Hard core" and "Soft core" courses. Hard core courses shall have 5 credits and the soft core courses shall have 4 credits. Also, to have better flexibility in introducing the courses, additional optional courses are offered under 'Soft Core' category. Open electives shall have 3 credits. Total credit for the programme shall be 92 including open electives.

Core courses are related to the discipline of the M.Sc. Mathematics programme. Hard core courses are compulsorily studied by a student as a core requirement to complete the programme. Soft core courses are electives but are related to the discipline of the programme. Two open elective courses of 3 credits each shall be offered in the II and III semester by the department.

Open elective will be chosen from an unrelated programme within the faculty.

Total credit for the M.Sc Mathematics programme is 92. Out of the total 92 credits of the programme, the hard core shall make up 58.69% of the total credits; soft core is 34.78% while the open electives will have a fixed 6 credits.

## COURSE IN TAKE:

The maximum number of students to be admitted to the course is 40.

## ELIGIBILITY:

As per Mangalore university Regulations.

# Semester wise distribution of credits for M.Sc. Mathematics programme

| Mathematics | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sem | Hard core | | | Soft core | | | Open elective | | | Others | | | Total |
| | No of papers | credits | Total credits | No of papers | credits | Total credits | No of papers | credits | Total credits | Computational Lab (soft core) | Project | credits | |
| I | 3 | 5 | **15** | 2 | 4 | **8** | | | | | | | **23** |
| II | 2 | 5 | **10** | 2 | 4 | **8** | 1 | 3 | **3** | 1(**2**) | | **2** | **23** |
| III | 3 | 5 | **15** | 1 | 4 | **4** | 1 | 3 | **3** | | | | **22** |
| IV | 2 | 5 | **10** | 2 | 4 | **8** | | | | 1(**2**) | 1(**4**) | **6** | **24** |
| **Total** | | | **50** | | | **28** | | | **6** | | | **8** | **92** |

**The following shall be the courses of study in the four semesters M.Sc. Mathematics programme (CBCS-PG) from the academic year 2021-22**

## I Semester

| Course Code | Course | Hard Core/Soft core/ Open elective | Credits |
|---|---|---|---|
| **PH 561.1** | Algebra I | HC | 5 |
| **PH 562.1** | Linear Algebra I | HC | 5 |
| **PH 563.1** | Real Analysis I | HC | 5 |
| **PS 564.1** | Graph Theory | SC | 4 |
| **PS 565.1** | Fluid Mechanics | SC | 4 |
| **PS 566.1** | Operations Research | SC | 4 |
| **PS 567.1** | Ordinary Differential Equations | SC | 4 |

## II Semester

| Course Code | Course | Hard Core/Soft core/ Open elective | Credits |
|---|---|---|---|
| **PH 561.2** | Algebra II | HC | 5 |
| **PH 562.2** | Real Analysis II | HC | 5 |
| **PS 563.2** | Research Methodology and Ethics | SC | 4 |
| **PS 564.2** | Linear Algebra II | SC | 4 |
| **PS 565.2** | Lattice theory | SC | 4 |
| **PS 566.2P** | Computational Lab-1 | SC | 2 |
| **PO 567.2** | Basic Tools in Mathematics | OE | 3 |

## III Semester

| Course Code | Course | Hard Core/Soft core/ Open elective | Credits |
|---|---|---|---|
| **PH 561.3** | Complex Analysis I | HC | 5 |
| **PH 562.3** | Topology | HC | 5 |
| **PH 563.3** | Numerical Analysis with Computational Lab | HC | 5 |
| **PS 564.3** | Commutative Algebra | SC | 4 |
| **PS 565.3** | Multivariate Calculus and Geometry | SC | 4 |
| **PS 566.3** | Probability Theory | SC | 4 |
| **PO 567.3** | Differential Equations and Applications | OE | 3 |

## IV Semester

| Course Code | Course | Hard Core/Soft core/ Open elective | Credits |
|---|---|---|---|
| **PH 561.4** | Measure Theory and Integration | HC | 5 |
| **PH 562.4** | Complex Analysis II | HC | 5 |
| **PH 563.4** | Project Work | HC | 4 |
| **PS 564.4** | Functional Analysis | SC | 4 |
| **PS 565.4** | Partial Differential Equations | SC | 4 |
| **PS 566.4** | Algebraic Number Theory | SC | 4 |
| **PS 567.4** | Cryptography | SC | 4 |
| **PS 568.4** | Distribution Theory | SC | 4 |
| **PS 569.4P** | Computational Lab-2 | SC | 2 |

# Scheme of Instruction and Examination

| M.Sc. Mathematics – 2021-22<br>I Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Hard Core/ Soft Core/ Open Elective** | **Instruction Hours per Week** | **Duration of Examination** | **Marks** | | | **Credits** |
| | | | | | **IA Marks** | **End Semester Marks** | **Total** | |
| PH 561.1 | Algebra I | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 562.1 | Linear Algebra I | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 563.1 | Real Analysis I | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PS 564.1 | Graph Theory | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 565.1 | Fluid Mechanics | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 566.1 | Operations Research | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 567.1 | Ordinary Differential Equations | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |

| M.Sc. Mathematics – 2021-22<br>II Semester | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Hard Core/ Soft Core/ Open Elective** | **Instruction Hours per Week** | **Duration of Examination** | **Marks** | | | Credits |
| | | | | | **IA Marks** | **End Semester Marks** | **Total** | |
| PH.561.2 | Algebra II | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 562.2 | Real Analysis II | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PS 563.2 | Research Methodology and Ethics | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 564.2 | Linear Algebra II | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 565.2 | Lattice theory | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 566.2P | Computational Lab-1 | SC | 3 | 2 hours | 15 | 35 | 50 | 2 |
| PO 567.2 | Basic Tools in Mathematics | OE | 3 | 3 Hours | 30 | 70 | 100 | 3 |

## M.Sc. Mathematics – 2021-22
## III Semester

| Course Code | Course Title | Hard Core/ Soft Core/ Open Elective | Instruction Hours per Week | Duration of Examination | Marks | | | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | | IA Marks | End Semester Marks | Total | |
| PH 561.3 | Complex Analysis I | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 562.3 | Topology | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 563.3 | Numerical Analysis with Computational Lab | HC | 4(theory)<br>2(Lab) | 3 Hours<br>2 hours | 30 | 70 | 100 | 5 |
| PS 564.3 | Commutative Algebra | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 565.3 | Multivariate Calculus and Geometry | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 566.3 | Probability Theory | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PO 567.3 | Differential Equations and Applications | OE | 3 | 3 Hours | 30 | 70 | 100 | 3 |

## M.Sc. Mathematics – 2021-22
## IV Semester

| Course code | Course Title | Hard Core/ Soft Core/ Open Elective | Instruction Hours per Week | Duration of Examination | Marks | | | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | | IA Marks | End Semester Marks | Total | |
| PH 561.4 | Measure Theory and Integration | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 562.4 | Complex Analysis II | HC | 5 | 3 Hours | 30 | 70 | 100 | 5 |
| PH 563.4 | Project Work | HC | 8 | - | 30 | 70 | 100 | 4 |
| PS 564.4 | Functional Analysis | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 565.4 | Partial Differential Equations | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 566.4 | Algebraic Number Theory | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 567.4 | Cryptography | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 568.4 | Distribution Theory | SC | 4 | 3 Hours | 30 | 70 | 100 | 4 |
| PS 569.4P | Computational Lab-2 | SC | 3 | 2 hours | 15 | 35 | 50 | 2 |

# PH 561.1 Algebra I

## Course Objectives:

To introduce the concepts and to develop working knowledge on Groups, Normal Subgroups, Finite groups, Rings and Fields.

## Course Outcomes:

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

**CO1** Identify the concept of Normal groups and Quotients groups.
**CO2** Investigate symmetry using group theory.
**CO3** Analyze Permutation groups and counting principle.
**CO4** Perform computations in symmetric groups
**CO5** Explain Sylow theorem and its applications.
**CO6** Provide information on ideals and Quotient rings, Field of Quotient of an integral domain

## Unit I:

**Groups:** The definition of a group, Sub group, cyclic groups and generators, Isomorphism, Homomorphism, Equivalence relations partitions, cosets, restriction of a homomorphism to subgroup products of groups, modular arithmetic, quotient groups. (15 Hours)

## Unit II:

**Symmetry:** Symmetry of plane figures, The groups of motions of the plane, finite groups of motions, discrete group of motions.
**Abstract symmetry:** Group operations, The operations on cosets, The counting formula, permutation representations. (15 Hours)

## Unit III:

**More on group theory:** The operation of a group on itself, Operations on subsets, The Sylow theorems, The groups of order 12, Computation in symmetric group, Orbits, Cycles and the alternating groups, Factor groups and the normal groups, Simple groups. (22 Hours)

## Unit IV:

**Rings and fields:** Definitions and basic properties, homomorphism and isomorphism, Divisors of zero and cancellation, Integral domains, The characteristic of a ring, The field of quotients of an integral domain, Rings of polynomials, The evaluation of homomorphisms, Factor rings and ideals, Fundamental homomorphism theorems, Prime and maximal ideals. (8 Hours)

## References:


1) Michael Artin – Algebra, Prentice Hall of India, 2nd edition, 2013
2) J. B. Fraleigh – A First Course in Abstract Algebra, Pearson, 7th edition,2002
3) I. N. Herstein – Topics in Algebra,John Wiley & Sons, 2nd edition, 2006
4) Joseph A. Gallian – Contemporary Abstract Algebra,Cengage Learning India, 8th edition,2013.
5) G. Birkhoff and S. Maclane – A Survey of Modern Algebra, Macmillan, New York, 3rd edition, 1953.
6) S. Lang – Algebra, Springer, 3rd edition, 2005.

# PH 562.1 Linear Algebra I

## Course Objectives:

To acquire knowledge about vector spaces, subspaces, bases and dimensions, linear transformations, their algebras and representation by matrices, the eigen values, eigen vectors, triangularization and diagonalization of matrices.

## Course outcomes:

A student will be able to

**CO1** gain knowledge of theory of matrices, and their operations

**CO2** solve linear system of equations

**CO3** learn the concepts of subspace, basis, linear independence, dimension of vector spaces and linear transformations

**CO4** understand the concept of Eigen values, eigen vectors

**CO5** understand the concept of diagonalization of matrices

**CO6** solve system of differential equations using matrix theory and compute matrix exponentials

## Unit I:

**Matrix Operations:** The Basic Operations, Row Reduction, Determinants, Permutation Matrices, Cramer's Rule. (12 hours)

## Unit II:

**Vector Spaces:** Real Vector Spaces, Abstract Fields, Bases and Dimensions, Computation with Bases, Infinite Dimensional Spaces, Direct Sums (22 hours)

## Unit III:

**Linear Transformation :** The Dimension Formula, The Matrix of Linear Transformation, Linear Operators and Eigenvectors, The characteristic Polynomial, Orthogonal Matrices and Rotations, Diagonalization, Systems of Differential Equations, The matrix Exponential. (26 hours)

## References:


1) Michael Artin – Algebra, Prentice Hall of India, 2nd edition, 2013
2) K. Hoffmann and R. Kunz – Linear Algebra, Prentice Hall of India, 2nd edition, 2013
3) S. Lang – Algebra, Springer, 3rd edition, 2005.
4) Larry Smith – Linear Algebra, Springer Verlag, 3rd edition, 1998.
5) Katsumi Nomizu – Fundamentals of Linear Algebra – McGraw Hill Company, 1966

# PH 563.1 Real Analysis I

## Course Objectives:

To introduce students to the fundamentals of mathematical analysis. The course objective is to understand the real number system, Metric spaces, compactness and connectedness of metric spaces and the concepts of limits, continuity, differentiability functions defined on subsets of the real line.

## Course Outcomes:

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

**CO1** Understand basic properties of $\mathbb{R}$, such as its characterization as a complete ordered field, Archimedean Property, density of $\mathbb{Q}$, countability and uncountability of sets.
**CO2** Classify and explain open and closed sets, limit points, compactness, connectedness etc. in a metric space.
**CO3** Use the definitions of convergence as they apply to sequences and series.
**CO4** Determine the continuity of functions in metric spaces
**CO5** Find the derivative of functions defined on subsets of the real line**.**
**CO6** Understand the differentiation of vector valued functions

## Unit I:

**The Real and Complex Number System:** Introduction, Ordered Sets, Fields, The Real Field, The Extended Real Number System, The Complex Field, Euclidean Spaces, Inequalities.
**Basic Topology:** Finite, Countable and Uncountable Sets, Metric Spaces, Compact Sets, Perfect Sets, Connected Sets. (20 hours)

## Unit II:

**Numerical Sequences and Series :** Convergent Sequences, Subsequences, Cauchy Sequences, Upper and Lower Limits, Some Special Sequences, Series, Series of Negative Terms, The Number e, The Root and Ratio Tests, Power Series, Summation by Parts, Absolute Convergence, Addition and Multiplication of Series, Rearrangements. (15 hours)

## Unit III:

**Continuity:** Limits of Functions, Continuous Functions, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic Functions, Infinite Limits and Limits at Infinity. (15 hours)

## Unit IV:

**Differentiation :** The Derivative of a Real Function, Mean Value Theorems, The Continuity of Derivatives, L'hospital's Rule, Derivatives of Higher Order, Taylor's Theorems, Differentiation of Vector Valued Functions. (10 hours)

## References:

1) Walter Rudin – Principles of Mathematical Analysis, McGraw Hill, 3rd edition, 2006

2) R. G. Bartle – The Elements of Real Analysis, Wiley International edition, New York, 2nd edition, 1976
3) T. M. Apostal – Mathematical Analysis, Addison / Wesley, Narosa, New Delhi, 2nd edition, 1985
4) G. H. Hardy – A Course in Pure Mathematics, Cambridge University Press, 10th edition, 2008.
5) R. R. Goldberg – Methods of Real Analysis, Oxford and I. B. H. Publishing Co., New Delhi, 2nd edition, 1970.

# PS 564.1 Graph Theory

## Course Objectives:

In this course basic concepts of Graph theory such as Trees, Eulerian Graphs, Hamiltonian Graphs, Colorings, Planarity are introduced.

## Course Outcomes:

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

**CO1** Write precise and accurate mathematical definitions of basics concepts in graph theory.
**CO2** Study the properties of trees and connectivity.
**CO3** Apply results to identify both Eulerian graphs and Hamiltonian graphs.
**CO4** Understand the concepts Planarity including Euler identity.
**CO5** Discuss and understand the importance of Coloring.
**CO6** Understand and apply various proof techniques in proving theorems in graph theory.

## Unit I:

**Graphs:** Varieties of graphs, Walks and connectedness, Degrees, The problem of Ramsey, Extremal graphs, Intersection graphs, Operations on graphs (10 Hours)

**Unit II:**
**Blocks:** Cut points, Bridges, Blocks, Block graphs and cut-point graphs.
**Trees:** Characterization of trees, Centers and centroids (15 hours)

**Unit III:**
**Connectivity:** Connectivity and line-connectivity, Menger's theorem. (8 hours)

**Unit IV:**
**Traversability:** Eulerian graphs, Hamiltonian graphs.
**Planarity:** Plane and planar graphs, Outer planar graphs.
**Colorability:** The chromatic number, The five color theorem, The chromatic polynomial. (15 hours)

**References:**


1) F. Harary – Graph theory, Addison-Wesley Series in Mathematics, 1969.
2) NarsinghDeo – Graph theory with Applications to Engineering and Computer Science, Prentice Hall of India, 2004.
3) K. R. Parthasarathy – Basic Graph Theory, The McGraw Hill Publishing Co. Ltd., New Delhi, 2nd edition,1994.
4) Douglass B. West – Introduction to Graph Theory, Prentice Hall of India, New Delhi, 2nd edition,2000.
5) O. Ore – Theory of Graphs, American Mathematical Society, Providence, Rhode Island,1967.

## PS 565.1 Fluid Mechanics

## Course Objectives:

This course aims at studying the fundamentals of fluid flow, its properties and behavior under various conditions of internal and external flows.

## Course Outcome:

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

- **CO1** the types of fluid flows, and understand the basic laws
- **CO2** the principles and phenomena in the area of fluid mechanics
- **CO3** derive Euler's equation of Motion and deduce Bernoulli's equations
- **CO4** to solve problems related to kinematics and dynamics of fluids, losses in a flow system, flow through pipes and flow past immersed bodies

**Unit I:**
Introduction: General description of fluid mechanics, Fluid properties, Types of fluids. Kinematics of fluids: Velocity , Material derivative and acceleration, Vorticity, velocity potential, Methods of describing fluid motion, types of fluid flow , flow patterns, Translation, Rotation and rate of deformation, Stress and strain. (8 hours)

**Unit II:**
Fundamental Equations of the Flow of compressible and Incompressible Fluids: The equation of continuity, Conservation of mass, Equation of motion, The energy equation, Conservation of energy. (12 hours)

**Unit III:**
One, Two, and Three Dimensional, Inviscid Incompressible Flow: The Bernoulli equation, Applications of Bernoulli equation, Circulation theorems, Stoke's theorem, Kelvin's theorem, Laplace equations, Steam functions ,
Two-dimensional flow: Source and sink, Radial flow, The Milne-Thomson circle theorem and applications, The theorem of Blasius. (14 hours)

**Unit IV:**
The Laminar Flow of Viscous Incompressible Fluids :The Reynolds number, Flow between parallel flat plates, Couette flow, Plane Poiseuille flow, Steady flow in pipes, Flow through a pipe, The Hagen-Poiseuille flow, Flow between two concentric rotating cylinders. (14 hours)

**References:**


1) S. W. Yuan - Foundations of Fluid Mechanics, Prentice Hall of India, 1976.
2) R. K. Rathy - An Introduction to Fluid dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
3) G. K. Batchelor -An Introduction to Fluid Dynamics: Foundation books, New Delhi, 2007.
4) F. Chorlton -Text book of Fluid Dynamics, CBS Publishers and Distributors, New Delhi, 2004.
5) J. F. Wendt, J. D. Anderson, G. Degrez and E. Dick - Computational Fluid dynamics: An Introduction, Springer-Verlag, 19

# PS 566.1 OPERATIONS RESEARCH

**Course Objectives**

This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making and to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

**Course Outcomes:**

On completion of this course students should be able to:

**CO1** Define and formulate linear programming problems and appreciate their limitations.

**CO2** Solve linear programming problems using appropriate techniques and interpret the results obtained.

**CO3** Explain the primal-dual relationship.

**CO4** Develop mathematical skills to analyse and solve transportation and assignment models arising from a wide range of applications.

**CO5** Understand the concept of game theory and learn its applications in different social situations.

**Unit I:**

Linear programming, Formulation and graphical solutions, (6 Hours)

**Unit II:**

Simplex Algorithm, Quality and sensitivity analysis, Dual Simplex method (18 Hours)

**Unit III:**

Transportation and assignment problems (14 Hours)

**Unit IV:**

Games and their solution by linear programming, Network Analysis (10 Hours)

**References:**


1) Hamdy A. Taha - Operations Research, Prentice Hall of India, 9th edition, 2010.
2) Hillier and Liberman - Introduction to Operations Research, McGraw Hill, 9th edition, 2012.

# PS 567.1 Ordinary Differential Equations

**Course Objectives:**

This course aims at learning the existence and uniqueness of solutions of ordinary differential equations, Solving second and higher order linear differential equations, solving linear systems of Ordinary Differential equations

**Course Outcomes:**

**CO1** Use the Wronskian to determine if a set of functions is linearly independent, construct a second solution to a second order differential equation by reduction of order.

**CO2** Find the complete solution of a homogeneous differential equation with constant coefficients by examining the characteristic equation and its roots.

**CO3** Find the complete solution of a nonhomogeneous differential equation with constant coefficients by the method of undetermined coefficients and by the method of variation of parameters.

**CO4** Solve basic application problems described by second order linear differential equations with constant coefficients.

**CO5** Identify ordinary and singular points and find power series solutions about ordinary points and singular points.

**Unit I:**

**Linear Differential Equations of Higher Order:** Linear dependence and Wronkinson, Basic theory for linear equations, Method of variation of parameters, Reduction of $n^{th}$ orders linear homogeneous equation homogeneous and non-homogeneous equations with constant coefficients.

(13 hours)

**Unit II:**

**Solutions in power series:** Second linear equations with ordinary, Legendre equation and Legendre polynomials, second order equations with regular singular points, Bessel equation.

(12 hours)

**Unit III:**

**Systems of Linear Differential Equations:** Systems of first order equations, Existence and uniqueness theorem. The fundamental matrix, Non-homogeneous linear systems, Linear systems with constant coefficients, Linear systems with periodic coefficients. (15 hours)

**Unit IV:**

**Existence and Uniqueness of Solutions:** Equations of the form $x' = f(t,x)$, Method of successive approximation, Lipschitz condition, Picards theorem, Non uniqueness of solutions , Continuation of solutions (08 hours)

**References:**


1) S. G. Deo and V. Raghavendra, Ordinary Differential equations and Stability Theory, Tata McGraw Hill, New Delhi, 1982
2) E. A. Coddington – An Introduction to Ordinary Differential Equations, Dover Publication, 2012
3) E. A. Coddington and N. Levinson – Theory of Ordinary Differential Equations, Tata McGraw Hill, New Delhi,2012
4) M. W. Hirsch and S. Smale – Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, New York, 3rd edition,2012.
5) V. I. Arnold – Ordinary Differential Equations, MIT Press, Cambridge, 2009.

# Second Semester

## PH 561.2 Algebra II

**Course Objectives:**
To grasp the fundamental principles and theory concerning basic algebraic structures such as integral domains, fields and extension fields.

**Course Outcomes:**
On completion of this course student should be able to:

**CO1** Understand the notion of irreducibility, primes and unique factorization
**CO2** Derive and apply Gauss Lemma, Eisenstein criterion for irreducibility of polynomials.
**CO3** Understand the concept of Factorization and ideal theory in the polynomial ring, the structure of Primitive polynomials
**CO4** Explain the concepts of Field extensions and characterization of finite normal extensions as splitting fields
**CO5** Understand the structure and construction of finite fields
**CO6** Analyze splitting fields, Galois extensions and Galois groups

**Unit I:**
**Divisibility in integral domains:** Irreducible, Primes, Unique factorization domains, Euclidean Domains. ( 10 Hours)

**Unit II:**
**Factorization of polynomials:** Content of polynomials, Primitive polynomials, Gauss lemma, Irreducibility test mod p, Eisenstein's criterion, Unique factorization in R[X]where R is a Unique Factorization Domain. (15 Hours)

**Unit III:**
**Fields:** Algebraic and Transcendental elements, the degree of a field extension, construction with a ruler and compass. Symbolic adjunction of roots, Finite fields, algebraically closed fields, The fundamental theorem of algebra. (20 Hours)

**Unit IV:**
**Galois Theory:** Splitting fields, Primitive elements, The main theorem of Galois theory. (15 Hours)

**References:**


1. Michael Artin – Algebra, Prentice Hall of India, 2nd edition, 2013
2. David S. Dummit and Richard M.Foot -Abstract Algebra, Wiley, 3rd edition, 2004
3. I. N. Herstein – Topics in Algebra,John Wiley & Sons, 2nd edition, 2006
4. Joseph A. Gallian – Contemporary Abstract Algebra,Cengage Learning India, 8th edition,2013.
5. J. B. Fraleigh – A First Course in Abstract Algebra, Pearson, 7th edition,2002
6. Serg Lang – Algebra,Springer, 3rd Edition, 2005.
7. I S Luther and I B S Passi – Algebra volume 2, NarosaPublishing House, 1999

## PH 562.2 Real Analysis II

**Course Objectives:**
The objective of this course is to give mathematical foundation to the concept of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration, pointwise and uniform convergence of sequences and series of functions, improper integrals and functions of several variables.

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

**CO1** Understand the definition of integrals and their properties
**CO2** Determine the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorems concerning integration
**CO3** Recognize the difference between pointwise and uniform convergence of sequences and series of functions.
**CO4** Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability and integrability.
**CO5** Evaluate improper integrals
**CO6** To gain knowledge on functions of several variables -The contraction principle, inverse function theorem and implicit function theorem.

**Unit I:**
**The Riemann-Stieltjes Integral :** Definition and existence of integrals, Properties of integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves.
(17 hours)

**Unit II:**
**Sequences and Series of Functions :** Discussion of main problem, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, The Stone-Weierstrass theorem. (19 hours)

**Unit III:**
**Improper integrals**: Definition, Criteria for convergence, Interchanging derivatives and integrals. (9 hours)

**Unit IV:**
**Functions of several variables:**, Differentiation, The contraction principle, The inverse Function theorem, The implicit function theorem. (15 hours)

**References:**


1) Walter Rudin – Principles of Mathematical Analysis, McGraw Hill, 3rd edition, 2006
2) Serge Lang-Analysis I, Addison Wesley Publishing Company,1968
3) R. G. Bartle – The Elements of Real Analysis, Wiley International edition, New York, 2nd edition, 1976
4) T. M. Apostal – Mathematical Analysis, Addison / Wesley, Narosa, New Delhi, 2nd edition, 1985
5) G. H. Hardy – A Course in Pure Mathematics, Cambridge University Press, 10th edition,2008.
6) R. R. Goldberg – Methods of Real Analysis, Oxford and I. B. H. Publishing Co., New Delhi, 2nd edition, 1970.

# PS 563.2  Research Methodology and Ethics

**Objectives of the Paper:**

To have clear understanding of the meaning and purpose of Research in academics and strategies of Research, to acquaint with the knowledge of methodology involved in a scientific Research, to understand the ethical issues and practices in research , understand the process of IPR, to know how to write research papers and publish research papers.

**Outcome of the Paper:**

**CO1** Quality research with scientific methodology

**CO2** Production of good Research Reports

**CO3** Original Research following ethical guidelines and practices in conducting the research and publication of papers.

**CO4** More awareness on Intellectual property Rights and Patents.

**Unit 1: Foundation of Research and Research Methodology:** (20 Hours)

Research – meaning, characteristics, objectives, motivation in research, need and importance of research. Types of Research, Concept of Theory and Theory Building, Research Problem – meaning, selecting the problem, sources of problem, statement of a problem; Review of Literature, sources of literature review, identification of research gap; Research Questions; Objectives of the study , Research Report – meaning, features and format, Appendices and References/ Bibliography – styles

**Unit 2: Mathematical Writing:** (18 Hours)

Essential rules of grammar, syntax and usage in mathematical writing; more specifics on writing a definition, theorem, writing proofs; mathematical research –meaning and objectives, writing a paper, collaborative work; usage of a Text Editor

**Unit 3: Research Ethics, Intellectual Property Rights (IPR) and Publication of Scholarly Papers** (10 Hours)

Ethics – meaning and definition, Scientific conduct – ethics with respect to science and research, scientific misconduct – falsification, fabrication and plagiarism. Publication ethics, publication misconduct, Violation of public ethics, authorship and contributorship, Predatory publishers and journals, Self-plagiarism

IPR – Concept of IPR, nature and characteristics of IPR, origin and development of IPR, Forms of IPR – copyrights, trademarks, patents, Publication – Scholarly/research article – meaning and features of scholarly article, Data base and Research – Data bases, Research Metrics

**References:**


- Kothari C R - Research methodology: Methods & Techniques. New Age International Publishers, New Delhi, $2^{nd}$ edition, 2014
- Walliman N - Your Research Project: A Step by Step Guide for the first time Researcher, Sage Publications, London, 2005
- Steven G Krantz - A Primer of Mathematical Writing. American Mathematical Society, $2^{nd}$ edition, 2016
- Ethics in Science Education, Research & Governance, Indian National Science Academy (INSA), 2019
- David I Bainbridge - Intellectual Property, Pearson, $10^{th}$ edition, 2018
- Jayashree Watal - Intellectual Property Rights in the WTO and Developing Countries. Oxford University Press, 2003

## PS 564.2 Linear Algebra II

**Course objectives:**
To acquire knowledge about bilinear forms on vector spaces, their properties, orthogonalization process, Spectral theorems and to learn the theory of Modules

**Course outcomes:**

Student will be able to

**CO1** Understand the concept of bilinear forms on vector spaces
**CO2** Derive spectral theorems for various types of operators on vector spaces
**CO3** Explain the theory of modules
**CO4** Apply the theory in diagonalization of matrices over rings

**Unit I:**

**Bilinear Forms:** Bilinear form, symmetric forms, orthogonality, the geometry associated to a positive form, Hermitian forms, the spectral theorems , skew symmetric forms, summary of results in matrix notation. (24 hours)

**Unit II:**

**Modules:** Module, Matrices, Free modules and bases, Diagonalization of integer matrices, Generators and relations for modules, The structure theorem for abelian groups, Application to linear operators.

(24 hours)

**References:**


1. Michael Artin – Algebra, Prentice Hall of India, 2nd edition, 2013
2. K. Hoffmann and R. Kunz – Linear Algebra, Prentice Hall of India, 2nd edition, 2013
3. S. Lang – Algebra, Springer, 3rd edition, 2005.
4. Larry Smith – Linear Algebra, Springer Verlag, 3rd edition, 1998.
5. Katsumi Nomizu – Fundamentals of Linear Algebra – McGraw Hill Company, 1966

# PS 565.2 Lattice Theory

## Course Objectives:

To introduce the students to the concepts of partially ordered sets, lattices, complete lattices, modular lattices and distributive lattices and examine their structural properties.

## Course Outcomes:

On completion of the course the student should be able to:

**CO1** understand the concept of Partially ordered sets and Their Properties.

**CO2** identify Lattices as posets and as Algebraic Structures and explain the theory of lattices in general.

**CO3** explain the concept of Complete Lattices and understand their properties.

**CO4** explain the concept of Modular and Distributive Lattices.

**Unit I:**

**Partially Ordered Sets:** Partially ordered sets (or posets) , Diagrams, Lower and Upper bounds, Order homomorphism and order isomorphism, Special subsets of poset, Axiom of choice, Zorn's lemma and Hausdorff's maximal chain principle and equivalence of these two statements, Length of a poset, The minimum and maximum conditions, Jordan – Dedekind chain condition, Dimensional functions, Duality principle for posets. (12 Hours)

**Unit II:**

**Lattices in general:** A lattice as a poset and as an algebra, Diagrams of lattices, Duality principles for lattices, Semi-lattices, Sub-lattices, Convex sub-lattices Ideals and prime ideals of lattices, Ideal generated by a non-empty subset of a lattice and it's description, Representation of convex sub-lattices in terms of ideals and dual ideal, The ideal lattice and the augmented ideal lattice of a lattice, Bound elements, Atoms and dual atoms in a lattice, Atomic lattices, Complemented, Relatively complemented and sectionally complemented lattices, Homomorphism, Congruence relations and quotient lattices of lattices, The homomorphism theorem, Complete lattices, Fixed point theorem for complete lattices. (24 Hours)

**Unit III:**

**Distributive and Modular Lattices:** Distributive, Infinitely distributive and Completely distributive lattices, Modular lattices, Characterization of modular and distributive lattices in terms of sub-lattices, The isomorphism theorem of modular lattices, Covering conditions, The prime ideal theorem for distributive lattices.

(12 Hours)

**References:**

1) G. Scasz – Introduction to Lattice theory, Academic Press, N. Y., 3rd edition, 1963.
2) G. Gratzer – General Lattice Theory, BirkhauserVerlag, Basel, 2nd edition,1996.
3) P. Crawley and R. P. Dilworth – Algebraic Theory of Lattices, Prentice – Hall Inc., N. J., 1973.
4) G. Birkhoff – Lattice Theory, American Mathematical Society Colloquium Publications, Volume 252, 3rd edition, 1995.
5) L. A. Skornjakov – Elements of Lattice Theory, Hindustan Publishing Corporation, 1997.

# PS 566.2P Computational Lab -1
# (using FOSS and Problem working)

## Course objectives:

To provide exposure to students to latest tools & technologies in the area of computer science to solve mathematical problems

## Course outcomes:

Upon completion of the course student will be able to:

**CO1** understand the usefulness of FOSS in Mathematical computations
solve problems in matrix theory using FOSS

**CO2** do computations with algebraic structures such as groups, rings and fields with the aid of FOSS

**CO3** test the continuity, differentiability of functions and evaluate limits

Introduction to FOSS,Computations with matrices, Solving system of equations, Linear independence, Linear combinations, Linear transformation to matrices conversion and vice versa, Matrix with respect to change of basis, Finding eigen values and eigen vectors, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization of the columns, Triangularization, Diagonalization, Singular value decomposition

Computation with groups, subgroups, normality, Verification of Lagrange's Theorem, Isomorphism theorem and Cayley's theorem,
Computation with rings, integral domains and fields, Solving polynomial equations, Test for rational roots.

Plotting functions, Continuity of a function, Differentiability of a function, Mean Value theorem and Taylor's series for a given function, Evaluation of limits by L'Hospital's rule, Evaluation of integrals

# PO 567.2 Basic Tools in Mathematics (OE)

## Course objectives:

To introduce students to the fundamentals of Mathematical analysis and Linear Algebra and to give sufficient knowledge of the subject, which can be used by the student for further applications in their respective domains of interest

## Course outcomes:

Upon completion of the course student will be able to:

- **CO1** know about the number system, countability and uncountability of sets
- **CO2** use the definitions of convergence as they apply to sequences and series
- **CO3** determine the limits, continuity and differentiability of functions defined on subsets of the real line.
- **CO4** know about optimization of functions of one variable
- **CO5** solve system of linear equations using Matrix theory
- **CO6** compute eigen values and eigen vectors

**Unit I:**

**Sequences and series:** Numbers, Some Properties of Point sets in $\mathbb{R}^n$ Functions, Sequences, Limit of a sequence, Properties of sequences, Series . (12 hours)

**Unit II:**

**Univariate Calculus and Optimization:** Continuity of functions, Intermediate Value theorem, Derivative and differential of functions of one variable, Conditions of differentiability, Rules of Differentiation, Higher order derivatives, Concavity and convexity, Taylor Series Formula and Mean Value Theorem.

Optimization of functions of one variable: Necessary condition for unconstrained maxima and minima, Second order conditions (14 hours)

**Unit III:**

**Linear Algebra:**

Matrices, basic operations, Row reduction, Solving System of linear equations in $n$ variables, Determinants and Eigen Values (10 hours)

**References:**

1.) Walter Rudin – Principles of Mathematical Analysis, McGraw Hill, 3rd edition, 2006

2.) Michael Hoy, Chris Mckenna, John Livernois, Ray Rees ,Thanasis Stengos- Mathematics for Economics, MIT Press, 3rd edition, 2011

3.) Michael Artin – Algebra, Prentice Hall of India, 2nd edition, 2013

4.) Joseph A Gallian- Contemporary abstract Algebra, Cengage Learning India, 8th edition, 2013

5.) John B Fraleigh - A First course in Abstract Algebra , Pearson, 7th edition, 2002

**The above list may be changed annually with the approval of PG Board of Studies in Mathematics.**

# III Semester

## PH 561.3 Complex Analysis I

**Course Objectives:**

This course is aimed to provide an introduction to the theories of functions of a complex variable. It begins with the exploration of the algebraic and geometric structures of the complex number field. The concepts of analyticity, Cauchy-Riemann relations and harmonic functions are also introduced.

**Course Outcomes:**

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

**CO1** Represent complex numbers algebraically and geometrically

**CO2** Define and analyze limits and continuity for complex functions.

**CO3** Apply the concept and consequences of analyticity and the Cauchy-Riemann equations

**CO4** Apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula

**CO5** To classify singularities and poles

**Unit I:**

**Complex numbers:** The algebra of complex numbers – Arithmetic operations, Square roots, Conjugation, Absolute value, Inequalities.

The geometric representation of complex numbers – Geometric addition and multiplication, The binomial equation, Analytic geometry, The spherical representation. (10 hours)

**Unit II:**

**Complex functions:** Introduction to the concept of analytic function – Limits and continuity, Analytic function, Polynomials, rational functions.

Elementary theory of power series – Sequences, Series, Uniform convergence, Power series, Abel's Limit theorem.

The exponential and trigonometric functions – The exponential, The trigonometric functions, The Periodicity, The logarithm.

Analytic functions as mappings:Conformality – Arcs and closed curves, Analytic functions in regions, Conformal mapping, Length and area. (18 hours)

**Unit III:**

**Linear transformation** – The linear group, The cross ratio, Symmetry.

Complex integration : Fundamental theorems, Line integrals, Rectifiable arcs, Line integrals as functions of arcs, Cauchy's theorem for rectangle, Cauchy's theorem for a disk.

Cauchy's integral formula : The index of a point with respect to a closed curve, The integral formula, Higher derivatives. (18 hours)

**Unit IV:**

**Local Properties of analytical Functions:** Removable singularities, Taylor's theorem, Zeros and poles, the local mapping, the maximum principle. (14 hours)

**References:**


1. Lars V. Alhfors – Complex analysis, McGraw Hill, 3rd Edition, 2000
2. B. R. Ash – Complex Variables, Dover Publications Inc., 2nd edition, 2007
3. R. V. Churchill, J. W. Brown and R. F. Verlag – Complex Variables and Applications, McGraw Hill, 8th edition, 2008
4. J. B. Conway – Functions of one Variable, Springer, 2nd edition, 1995
5. Joseph Bak, Donald J. Newman–ComplexAnalysis,Springer international, 3rd edition, 2010
6. S. Ponnuswamy – Foundations of Complex Analysis, Alpha Science Intl Ltd. , 2nd edition, 2006

## PH 562.3 Topology

### Course Objectives:

Define and illustrate the concept of topological spaces and continuous functions, product topology, compactness, connectedness and the concepts of separation axioms**.**

### Course Outcomes:

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

**CO1** Define a topology , a basis for a toplogy and various types of topologies
**CO2** To construct topological spaces from metric spaces.
**CO3** Gains knowledge on general properties of neighborhoods, open sets, closed sets, basis and sub-basis.
**CO4** Apply the properties of open sets, closed sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems.
**CO5** Understand the concepts and properties of compact and connected topological spaces.
**CO6** Gain knowledge on the concepts of countable spaces and separable spaces.

**Unit I**

**Topological spaces:** Elements of Topological spaces, basis for a topology, the order topology, the product topology on $X \times Y$, the subspace topology, closed sets and limit points.

(17 hours)

**Unit II**

Continuous functions, the product topology, metric topology. (12 hours)

**Unit III**

**Connectedness and Compactness:** connected spaces, connected subspaces of the real line, components and local connectedness, compact spaces of the real line, limit point compactness, and local compactness. (16 hours)

**Unit IV**

**Countability and separation axioms:** the countability axioms, the separation axioms, normal spaces, the Urysohn lemma, the Uryson metrization theorem, Tietze extension theorem.

(15 hours)

**References:**

1) J. R. Munkres -Topology, Prentice Hall of India, 2nd Edition, 2015.
2) Simmons, G. F. - Introduction to topology and modern analysis, McGraw Hill, 2004.
3) Dugundji J. -Topology, Prentice Hall of India, 1966
4) Willard - General Topology,Dover Publication, 2012
5) Crump, W. Baker - Introduction to Topology, Krieger PublishingCompany,1997.

## PH 563.3 Numerical Analysis with Computational Lab

**Course Objectives:**

The purpose is to provide the students with the skills and knowledge required to determine approximate numerical solutions to mathematical problems which cannot always be solved by conventional analytical techniques, and to demonstrate the importance of selecting the right numerical technique for a particular application, and carefully analyzing and interpreting the results obtained**.**

**Course Outcomes:**

On completion of this course the student should be able to:

**CO1** Apply appropriate algorithms to solve selected problems, both manually and by writing computer programs.

**CO2** Compare different algorithms with respect to accuracy and efficiency of solution.

**CO3** Analyze the errors obtained in the numerical solution of problems.

**CO4** Demonstrate the use of interpolation methods to find intermediate values in given graphical and/or tabulated data.

**CO5** Using appropriate numerical methods, determine approximate solutions for problems of differentiation and integration.

**CO6** Using appropriate numerical methods**,** determine approximate solutions to ordinary differential equations.

**Unit I: Transcendental and Polynomial Equations:**

Introduction: Direct Methods, Iterative Methods, Initial approximations,Bisection Method Iteration Methods Based on First Degree Equation: Secant and RegulaFalsi method, Newton Raphson method.

Iteration Methods Based on Second Degree Equation: Muller Method, Chebyshev method General Iteration Methods: First Order method, Second Order Method, Higher Order Methods, Acceleration of the convergence, Efficiency of a method, Methods for Multiple roots .

Polynomial Equations: Synthetic Division, Birge-Vieta Method, Bairstow Method
System of Linear Algebraic Equations and Eigenvalue Problems:
Introduction, Direct methods: Gauss Elimination Method, Gauss-Jordan Method, Triangularisation Method, Cholesky Method
Iteration Methods: Jacobi Iteration Method, Gauss Seidel Iteration Method
Eigenvalues and Eigenvectors, Bounds on Eigenvalues Power method, Inverse Power Method. (12 hours)

**Unit II: Interpolation and Approximation**

Introduction, Interpolation: Lagrange and Newton Interpolations, Iterated linear Interpolation, Newton's Divided difference Interpolation, Truncation Error Bounds,
Interpolating Polynomials using Finite Differences: Gregory-Newton Forward Difference interpolation, Gregory-Newton Backward Difference Interpolation,
Hermite Interpolation
Least Square Approximation (12 Hours)

**Unit III: <u>Differentiation and Integration</u>**

Numerical Differentiation: Methods based on Interpolation,Methods Based on Finite Differences,Methods Based on Undetermined Co-efficient
Numerical Integration: Methods Based on Interpolation, Methods Based on Undetermined Co- efficient, Gauss Quadrature methods
Integration Methods of Gaussian Type with Pre-assigned Abscissas: Lobatto Integration methods, Radau Integration Methods
Composite Integration Methods: Trapezoidal Rule, Simpson's Rule
Double Integration: Trapezoidal Method, Simpson's Method. (12 Hours)

**Unit IV: <u>Ordinary Differential Equations</u>**

Initial Value Problems
Introduction, Numerical Methods: EulerMethod, Backward Euler Method, Mid-Point Method, Single Step Methods: Taylor Series Method,,Runge Kutta Second order Method, Runge - Kutta Fourth order method, Multistep Methods:
Explicit Multistep Methods (Adams-Bashforth Methods, Nystrom Methods), Implicit Multistep Methods ( Adams-Moulton Method, Milne – Simpson Method)

Boundary Value Problems
Introduction, Difference methods, Boundary value problems for $y^{||} = (x, y)$, Trapezoidal, Dahlqist and Numerov methods

(12 hours)

**References:**

1.)M.K.Jain, S.R.K.Iyengar, R.K.Jain: Numerical Methods for Scientific and Engineering Computation, New Age Internnational, 6th edition, 2012

2.)C.F.Gerald and P.O.Wheatly-Applied Numerical Analysis,Pearson Education Inc., 1999

3.)M.K.Jain- Numerical Solution of Differential Equations, New Age International (P) Ltd, New Delhi, 2nd edition,1984

**Computational Lab (Scilab)**

1. Regula - Falsi method.
2. Secant method.
3. Newton - Raphson method.
4. Chebyshev method.
5. Birge - Vieta method .
6. Bairstow method.
7. Gauss - Jacobi method.
8. Gauss - Seidal method.
9. Trapezoidal method.
10. Simpson $\frac{1}{3}$ rd method.
11. Program to solve the initial value problem using Euler method.
12. Program to solve the initial value problem using modified Euler method
13. Program to solve the initial value problem using Runge Kutta 2nd order method.
14. Program to solve the initial value problem using Adam - Bashforth method.
15. Program to solve the initial value problem using Milne - Simpson method.

# PS 564.3 Commutative Algebra

**Course Objectives:**
The course develops the theory of commutative rings. These rings are of fundamental significance since geometric and number theoretic ideas is described algebraically by commutative rings.

**Course Outcomes:**
The student will learn

**CO1** basic definitions concerning elements in rings, classes of rings, and ideals in commutative rings.
**CO2** constructions of rings of fractions and modules of fractions, localization at prime ideals
**CO3** the concept of Noetherian rings and Hilbert basis theorem.
**CO4** the primary decomposition of ideals in Noetherian rings.

**Unit I:**
**Rings and Ideals :** Zero divisors, Nilpotent elements, Units, Prime ideals and maximal ideals, Nilradical and Jacobson radical, Operations on ideals, Extensions and contraction of ideals. The prime spectrum of a ring.
(14 Hours)

**Unit II:**
**Modules :** Operations on Submodules, Isomorphism theorems, Direct sum and product, Finitely generated modules, Nakayama's Lemma, Exact sequences (omit tensor products and related results).
(8 Hours)

**Unit III:**
**Rings and Modules of Fractions**: Local properties, Extended and contracted ideals in rings of fractions. (14 Hours)

**Unit IV:**
**Primary Decomposition**: The first and the second uniqueness theorems Noetherian rings and modules, Primary Decomposition in Noetherian rings. (12 Hours)

**References:**

1) M. F. Atiyah and I. G. Macdonald-Introduction to Commutative Algebra ,Sarat Book House, 2007
2) Commutative Algebra- N. Bourbaki, American Mathematical Society, Addison Wesley, 1972.
3) Commutative Algebra- N. S. Gopalkrishnan, Orient Blackswan, 2nd edition, 2015
4) D. G. Northcott Lesson on Rings, Modules and Multiplicities- Cambridge University Press, 2008.
5) Commutative Algebra – O. Zariski and P. Samuel, Springer, 1975

# PS 565.3 Multivariate Calculus and Geometry

**Course Objectives:**
This course aims at familiarizing the students with the concepts of level sets, tangent spaces, line integrals, double integration, surface integrals, Gaussian curvature and geometry of curves and surfaces in $\mathbb{R}^3$.

**Course Outcomes:**
On completion the student should be able to:
**CO1** account for important theorems and concepts in multivariate analysis.
**CO2** account for the most common multivariate methods.
**CO3** explain the geometry of curves on $\mathbb{R}^3$.
**CO4** explain the geometry of surfaces on $\mathbb{R}^3$.

**Unit I:**
Level sets and tangent spaces, Lagrange multipliers, Maxima and minima on open sets.
(12 Hours)

**Unit II:**
Curves in $R^n$, Line integrals, The Frenet – Serret equations, Geometry of curves in $R^3$
(12 Hours)

**Unit III:**
Double integration, Paramatrised surfaces in $\mathbb{R}^3$ , surface area, Surface integrals
(12 Hours)

**Unit IV:**
Geometry of surfaces in $\mathbb{R}^3$ , Gaussian curvature, Geodesic curvature.
(12 Hours)

**References:**


1) Sean Dineen – Multivariate calculus and Geometry, Springer Undergraduate Mathematics Series,3rd edition, 2014

2) Walter Rudin – Principles of Mathematical analysis, McGraw Hill, New York, 3rd edition, 2006

3) Andrew Pressly – Elementary Differential geometry, Springer Undergraduate Mathematics Series, 2nd edition, 2010

4) J. A. Thorpe – Elementary Topics in Differential Geometry, Undergraduate Texts in Mathematics, Springer Verlag, 1979

5) W, Klingenberg – A Course in Differential Geometry, Springer Verlag, 1978

## PS 566.3 Probability Theory

**Course Objectives:**
To demonstrate an understanding of the basic principles of probability theory and the use of the various families of probability distributions to model various types of data. This course also provides an understanding of random sampling, theory of estimation and testing of hypotheses

**Course outcomes:**
A student will be able to

**CO1** Develop problem-solving techniques needed to accurately calculate probabilities

**CO2** Apply problem-solving techniques to solving real-world events.

**CO3** Understand the properties of discrete and continuous random variables with their joint, marginal, and conditional distributions

**CO4** Apply selected probability distributions to solve problems.

**Unit I:** Classes of sets, Limit superior and limit inferior of a sequence of sets, Fields, sigma - field, minimal sigma-field, Borelsigma field on R. Probability measure and its properties.

(6 hours)

**Unit II:** Random variables, algebra of random variables, sequences of random variables, Probability measure induced by a random variable. Distribution functions of a random variable, its properties. Decomposition of a distribution functions into discrete and continuous parts.

(15 hours)

**Unit III:** Expectation of a random variable, Monotone convergence theorem, Statement of Dominated convergence theorem, Convergence in distribution, convergence in probability, properties and examples. (12 hours)

**Unit IV:** Almost sure convergence, convergence in $r^{th}$ mean, Borel-Cantelli Lemma, Khintchine and Chebychev's weak law of large numbers, Kolmogorov's generalized weak law of large numbers (proof of sufficiency part only), Kolmogorov's strong law of large numbers, Sequence of independent and iid random variables. (15 hours)

**References:**


1. Ash, R.B. and Doleans-Dade, C.A. - Probability and Measure Theory, Academic Press, New York, 2nd edition,2000.
2. Bhat, B.R. - Modern Probability Theory, New Age International, New Delhi, 2nd edition, 1999
3. Billingsley, P. - Probability and Measure, John Wiley, New York, 3rd edition, 1995
4. Burril, C.W. -Measure, Integration, and Probability,McGraw-Hill International, New York, 1972
5. Chung, K.L. - A Course in Probability, Academic Press, New York, 3rd edition, 2001
6. Clarke, L.E. - Random Variables, Longman Mathematical Texts, London, 1975
7. Rao, C.R. -Linear Statistical Inference and Its Applications,John Wiley, New York, 1973

# PO 567.3 Differential Equations and Applications (OE)

**Course Objectives:**

To develop analytical techniques to solve differential equations and to use the techniques learnt for applications of differential equations.

**Course Outcomes:**

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

**CO1** Find solution of first order and second order ordinary differential equations using different methods.

**CO2** Apply different techniques to solve differential equations in Applied Mathematics.

**CO3** Find solution of first order and second order partial differential equations using different methods.

**CO4** Find solution of wave equation and Heat equation.

**Unit I:**
**Introduction to Differential Equations**

Definition, Order and Degree of a differential equation, First order differential equations - variable separable method, Homogeneous equations, linear equations, Applications

(12 hours)

**Unit II:**
**Differential Equations of Second order**

Homogeneous and non-homogeneous differential equations, Linear differential equations with constant coefficients, Differential operators, Particular Integral, Method of Variation of Parameters, Applications

(12 hours)

**Unit III:**
**Partial Differential Equations**

Linear homogeneous partial differential equations with constant coefficients, Rules for finding the complementary function, General Rules of finding the Particular Integral, Non-homogeneous linear equations, Applications

(12 hours)

**References:**


1.H.K. Dass and Rama Verma – Mathematical Physics, S Chand, 2010
2 Kreyszig –Advanced Engineering Mathematics, Wiley, 10th edition,2011
3.G. F. Simmons –Differential Equations with Applications and Historical Notes, CRC Press, 3rd edition, 2016
4. E. D. Rainville and P. Bedient – Elementary course on Ordinary Differential Equations, Prentice Hall of India, 8th edition, 1996
5. K. Sankara Rao –Introduction to Partial Differential Equations, PHI, 3rd edition, 2010

# IV Semester

## PH 561.4 Measure Theory and Integration

**Course Objectives**

The aim is to introduce the students to the theory of Lebesue measure, Lebesgue integrals, abstract measure spaces and $L^p$ spaces.

**Course Outcomes:**
On completion the student should be able to:

- **CO1** give a more rigorous introduction to the theory of measure.
- **CO2** Understand the notions of measurable sets and functions
- **CO3** develop the ideas of Lebesgue integration and its properties.
- **CO4** identify measurable functions.
- **CO5** construct the Lebesgue integral and understand properties of the Lebesgue integral.
- **CO6** Learn inequalities in $L^p$ Spaces, signed measures and their derivatives

**Unit I:**
**Measure on the Real Line**: Introduction – Lebesgue outer measure-measurable sets-Borel sets-Regular measure – Lebesgue measurable function-Borel measurable function. (12 Hours)

**Unit II:**
**Integration of Functions of a Real Variable:** Integration of non-negative functions- Lebesgue integral- Fatou's lemma – Lebesgue monotone convergence theorem-Lebesgue Dominated convergence theorem-Riemann and Lebesgue integrals. (12 Hours)

**Unit III:**
**Abstract Measure Spaces:** Measurable and outer measures – Lebesgue Measure in Euclidean space – completion of a measure - measure spaces.
(12 Hours)

**Unit IV:**

**Inequalities and the $L^p$ Spaces**

Convex functions – Jensen's inequality – inequalities of Holder and Minkowski - $L^p$ - convergence in measure. (12 Hours)

**Unit V:**

**Signed Measures and their Derivatives**: Signed measures and Hahn decomposition –The Jordan decomposition (12 Hours

**References:**


1) G. de Barra - Measure Theory and Integration**,** Woodhead Publications, 2nd edition, 2003
2) Munroe, M. E. – Introduction to Measure and Integration – Addison Wesley, Mass 1953.
3) I. P. Natanson – Theory of Functions of a Real Variable –Dover Publications, 2016
4) Royden – Real Analysis, PHI, 4th edition, 2011
5) P. R. Halmos – Measure theory, Springer International Student Edition, 2nd edition, 1978
6) I. K. Rana – An Introduction to Measure and Integration, Narosa Publishing House, 2nd edition, 2010

## PH 562.4 Complex Analysis II

**Course Objectives:**

To, General form of Cauchy's Theorem, Residue theorem, argument principle, Mean value property, Reflection Principle etc. and to learn Taylor's series, Laurent's series and infinite products.

**Course outcomes:**

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

**CO1** To understand and apply results on analytic, harmonic and entire functions.

**CO2** Gain knowledge on simply connected and multiply connected regions

**CO3** Represent functions as Taylor, power and Laurent series,

**CO4** Classify singularities and poles, find residues

**CO5** Evaluate complex integrals using the residue theorem.

**CO6** Gain knowledge on infinite products, canonical products and Gamma function.

**Unit I:**

**The general form of Cauchy's theorem:** Chains and Cycles, Simple connectivity, Homology, The general statement of Cauchy's theorem, (Statement only). Locally exact differentials, Multiply connected regions. (10 hours)

**Unit II:**

**The Calculus of Residues:** The Residue theorem, the argument principle, Evaluation of definite integrals. (10 hours)

**Unit III:**

**Harmonic Functions:** Definition and basic properties, The mean value property, Poisson's formula, Schwarz's theorem, the reflection principle. (14 hours)

**Unit IV:**

**Series and Product Developments**: Power series expansions – Weierstrass's theorem, The Taylor series, The Laurent series. (12 hours)

**Unit V:**

**Partial Fractions and Factorizations:** Partial fractions, Infinite products, Canonical products, The Gamma function, Jensen's formula, Product development of the Riemann-Zeta function**.**

(14 hours)

**References:**


1. Lars V. Alhfors – Complex analysis, McGraw Hill, 3rd Edition, 2000
2. B. R. Ash – Complex Variables, Dover Publications Inc., 2nd edition, 2007
3. R. V. Churchill, J. W. Brown and R. F. Verlag – Complex Variables and Applications, McGraw Hill, 8th edition, 2008
4. J. B. Conway – Functions of one Variable, Springer, 2nd edition, 1995
5. Joseph Bak, Donald J. Newman – ComplexAnalysis,Springer international, 3rd edition, 2010
6. S. Ponnuswamy – Foundations of Complex Analysis, Alpha Science Intl Ltd. , 2nd edition, 2006

# PH 563.4 Project Work

**Guidelines for the preparation, presentation and evaluation of students research projects of IV semester (Science Faculty)**

**Preamble**

Research based learning has become an integral part of education at higher level. Autonomy provided to the college has created opportunities for introducing innovativeness through effective learning. In this regard, the choice based credit system introduced to postgraduate programmes from the year 2016-17 has introduced the concept of project work in the fourth semester for four credits. Research projects play an important role in the curriculum, wherein students develop a research culture by going through the published research articles, documents, choosing a relevant problem, preparing and collecting relevant materials/samples, analyzing and characterising them to arrive at their own findings and conclusions. It is a work that a student must do largely under his / her own direction, in the field of the chosen area, however faculty members will extend their help and guidance towards the implementation of the project work.

This guideline describes the procedures to be followed in the due course of implementation of the project. It outlines the general rules and regulations which govern the project, in terms of research work both theoretical and experimental, preparation of thesis and presentation/publication.

**Planning the Project Work**

The Students are advised to begin choosing relevant area of their interest during the third semester itself. However by the end of third semester he/she should meet the Head of the department with few project plans of his choice in the order of priority.

**Allotment of the Project Work**

By the end of third semester, the Head of the department in consultation with other members of his/her department, study the feasibility of the student's proposal in terms of materials(chemicals), facility, space and cost effectiveness, expertise in the relevant area etc. and allot a group of students to a particular project and a supervisor. By and large student's selected area is allotted without any bias.

**The Role of Supervisor**

The supervisor will able to advise the student about all aspects of the project as it unfolds. He/she must able to foresee the relevance, applicability and its uniqueness. He will constantly monitor the progress and the quality of the work and give appropriate direction as and when it demands through his/her availability in the department/Lab. He/she also make the student aware of inadequate progress or any other facts which could impede the completion of a successful piece of work.

**Responsibilities of the Student**

A student should spend a minimum of 8 hours for the project in the library by referring the articles or in laboratory by doing the experimental work in a week throughout the fourth semester. Student should try to keep supervisor informed about progress and plans in respect of project. To make appointments with the supervisor on a regular basis, if he / she is facing difficulty in arranging appointments he /she must contact the Head of Department.

Student should submit at least two written progress reports prior to the presentation in the department.

Students should accept the constructive criticism of the supervisor in the point of improving the quality of research work of his/her project.

Format of the thesis/report is attached at the end

**Award of Internal assessment marks (out of 30)**

1. Action plan: Review of literature/ plan of work/ Synopsis**: 10 marks**
2. Actual work, results, interactions and regular submission of reports**: 10 marks**
3. Presentation in front of all members of the department before preparing the final thesis; ( The faculty members may fine tune or give suggestions to improve the quality of final work at this stage): **10 marks**

**External examination**

External examination will be conducted in a similar manner to practical examinations. A group of 10-12 students allotted to a batch. One internal and one external examiner approved by Board of studies of the concern department will conduct *viva-voce.*

The marks are distributed as follows (out of 70)

- Thesis (report) content: **45 marks**

(45 marks are split into 40+5; Out of 45 marks, 3 marks are allotted to the student, who present the paper in any conference and the remaining 2 marks are allotted for the student if he/she wins a prize in the paper presentation.

- Presentation in the final examination: **15 marks**
- *Viva-voce*:**10 marks**

Student should prepare one or two (if demanded by the department) copies of the report which he/she can preserve for themselves after the final *viva-voce.*

Note: Due to lack space to keep bound copies of the project reports, the department may instruct the students to submit the department (library) copy of the project report in compact disc (CD) form. However good projects (at least 3 to 5 in a year) which are worth referring can be preserved in the bound copy form in the department. The same can be used to present before committees (NAAC, DST, LIC etc.) at the time of inspection. This can be told to students in their pre-*viva* presentation (presentation in the department).

**Project Report Format**

COVER PAGE (AS PROVIDED)

FRONT PAGE (AS PROVIDED)

CERTIFICATE (AS PROVIDED)

ACKNOWLEDGEMENT

DECLARATION (AS PROVIDED)

CONTENTS

1. INTRODUCTION
2. REVIEW OF LITERATURE
3. AIM AND OBJECTIVE
4. METHODOLOGY / EXPERIMENTATION / MATERALS & METHODS
5. RESULTS and DISCUSSION
6. CONCLUSIONS
7. REFERENCES

- **INTRODUCTION**: This includes the background of the work, lacuna if any in previous work and importance of the present work. The last part of introduction must highlight the objectives. The objectives should give a clear picture of the project.
- **REVIEW OF LITERATURE**: Includes the study and experimentation carried out by other workers on the topic which is being studied in the present project. The subheadings may be given at appropriate places for covering the topic under consideration. The subheadings may be appropriately numbered, eg, 2.1, 2.1.1 2.2, etc. The literature must be cited with suitable references e.g. (Subbiah*et al.*, 2005), ( Ravi and Harish 2009) etc.

- **MATERIALS AND METHODS**: The write -up must include the Materials used for the project work. Brand names of equipments and chemicals need to be specified. The methodology must be described briefly (the main principle involved is sufficient) citing the reference from which it is based. Only if the method is new, give detailed explanation.
- **RESULTS AND DISCUSSIONS**: This chapter must include the results of the project developed. The results must be depicted as figure, tables, graphs etc. Also the results must be explained in words. The comparison of the results, statisitical significance of the results should be discussed in this chapter. The concluding remarks may be included specifying how the project can help the end user.
- **CONCLUSIONS:** This includes the end result derived from the project and any further scope of research which can be carried out using the present work.
- **REFERENCES :** At the end of the report 30 to 50 references relevant to the topic chosen should be given. The style of reference can be chosen according to any good international journal of the concern PG program. It is left to the desecretion of the department.

**<u>Examples to write the references</u>**

**BOOKS with an author**

Author's surname, initials. (full stop)Year. (in brackets) (full stop) Title of book. (Underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Smith, P. (1999). How to write good assignments. Penguin Books, Ringwood.

**BOOKS with an editor**

Editor's surname, initials. (full stop) (ed.) (in brackets) Year. (in brackets) (full stop) Title of book. (underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Mawson, S. (ed.) (2001). Easy assignment writing. Doubleday Books, Sydney

**CHAPTER IN AN EDITED BOOK**

Chapter author's surname, initials. (full stop) Year. (brackets) (full stop) Title of chapter. (full stop) Followed by In: (underlined) (colon) Editor's surname, initials. (full stop)
(ed.) (in brackets) Title of book. (underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Woods, K. (2002). Dog grooming for beginners. In: Jolley, R. (ed.) Pets are people. Harper Collins, Melbourne.

**JOURNAL ARTICLES**

Author's surname, initials (full stop) Year. (in brackets) (full stop) Title of the article. (full stop) Title of the journal. (underlined OR italics) (full stop) Volume, number, month/season, (comma) Page number of article. (full stop)

1. Eg; Byrne, P. (1992).All about friends.The Journal of Relationships.No.12, December, pp1-13.
2. Jagetia GC, Reddy TK. The grape fruit flavonoid naringinprotectsagainst the radiation induced genomic instability in the mice bone marrow: a micronucleus study. Mutation research 2002;519(2):37-46. (Biochemistry/ Biotechnology )
3. M. Dutta, S. Mridha, D. Basak, Appl. Surf. Sci. 254 (2008) 2743.(Physics)
4. Y. He, P. Sharma, K. Biswas, E. Z. Liu, N. Ohtsu, A. Inoue, Y. Inada, M. Nomura, J. S. Tse, S. Yin, and J. Z. Jiang, Phys. Rev. B 78, 155202 (2008). (Physics)

**WORLD WIDE WEB**

Author's surname, initials. (full stop)Year. (in brackets) (full stop) Title (underlined OR italics) [Internet]. [in square brackets] (full stop) Publisher, (comma) Place of publication. (full stop) Available from: <URL> [accessed date].

Eg: Holland, M. (1996). Harvard System [Internet].Bournemouth University, Poole. Available from: http://www.bournemouth.ac.uk/library/using/harvard_system.html [Accessed 1 November 2004].

**Note:**

Good quality white executive bond paper A4 size should be used for typing and duplication. Care should be taken to avoid smudging while duplicating the copies.

**The text of the contents: Times new roman font-12, line spacing 1.5**

**There should be a minimum of 50 pages and a maximum of 75 pages in the report.**

Page Specification:

Left margin - 3.0 cm
Right margin- 2.0 cm
Top margin- 2.54cm
Bottom margin 2.54 cm

**Page numbers** - All text pages should be numbered at the bottom center of the pages.

**Normal Body Text: Font Size**: 12, Times New Roman, 1.5 Spacing, Justified. 6 point above and below para spacing

**Paragraph Heading Font Size:** 14, Times New Roman, Left Aligned. 12 point above & below spacing.

**Chapter Heading Font Size:** 16, Times New Roman, Centre Aligned, 30 point above and below spacing.

COVER PAGE

**TITLE**

(Times New Roman, Font 20, Capitals, Bold)

A Project Report

Submitted by

(Times New Roman, Font 12)

**NAME**

(**REG.NO.**)

(Times New Roman, Font 12, Bold, Capital)

to

**ST ALOYSIUS COLLEGE**

(Times New Roman, Font 20, Bold, Capital)

(AUTONOMOUS)

(Times New Roman, Font 12, Capital)

In part fulfilment of the requirements for the award of

**Master of Science**

(Times New Roman, Font 16,)

**DEPARTMENT NAME**

(Times New Roman, Font 16,Capital,)

**Department of PG Studies in Department Name and Research**

(Times New Roman, Font 16)

April, 2018

(Times New Roman, Font 16)

FRONT PAGE

**TITLE**

(Times New Roman, Font 20, Capitals, Bold)

A Project Report
Submitted by
(Times New Roman, Font 12)

**NAME**

(**REG.NO.**)

(Times New Roman, Font 12, Bold, Capital)

Under the guidance of

(Times New Roman, Font 12)

**GUIDE NAME**

(Times New Roman, Font 12, Bold, Capital)

to

**ST ALOYSIUS COLLEGE**

(Times New Roman, Font 20, Bold, Capital)
(AUTONOMOUS)
(Times New Roman, Font 12, Capital)

In part fulfilment of the requirements for the award of

**Master of Science**

(Times New Roman, Font 16,)

**DEPARTMENT NAME**

(Times New Roman, Font 16,Capital,)

**Department of PG Studies in Department Name  and Research**

(Times New Roman, Font 16)

April, 2018

(Times New Roman, Font 16)

## CERTIFICATE

This is to certify that the project report entitled "-------------**Title-----------------**" is a bonafied work carried out by -----------**Name-------------**, ----**Reg.No.----** under the guidance of ------**Guide Name ------** in the Department of PG Studies in Department Name and Research, St. Aloysius College.

The same is being submitted to the Post Graduation Department of Department Name , St. Aloysius College in partial fulfilment of the requirements for the award of **Master of Science-Department Name** . No part of this thesis has been presented for the award of any other degree.

Name & Signature of HOD Name & Signature of the Guide

## ACKNOWLEDGEMENT

In the "Acknowledgement" page, the writer recognizes his/her indebtedness for guidance and assistance of the different persons and members of the faculty. Courtesy demands that he/she also recognize specific contributions by other persons or institutions such as libraries and research foundations/funding agencies. Acknowledgements should be expressed simply, tastefully, and tactfully.

## DECLARATION

I/We, ------**Name**-------- hereby declare that the project work entitled "--------------------**Title------------**" is my original work and has been carried out under the guidance of **-------------Guide Name-----------------------, PG Department of Department Name , St. Aloysius college** is being submitted to the **Department of PG Studies in Department Name and Research, St. Aloysius college** in partial fulfilment of the requirements for the award of **Master of Science-Department Name** .

I also hereby declare that this work, in part or full, has not been submitted to any other University/Institution for any Degree/Diploma.

Date of Submission: Signature of the candidate

NAME

(REG.NO.)

**Signature of the Guide**
**NAME**

## PS 564.4 Functional Analysis

**Course Objectives**

This course includes analysis of Banach spaces, Hilbert spaces and theory of operators on Hilbert spaces.

**Course Outcomes:**

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

**CO1** explain the fundamental concepts of functional analysis.

**CO2** understand the definitions of linear functional and prove theorems such as the Hahn-Banach theorem, Open Mapping theorem and Uniform Boundedness Principle.

**CO3** define linear operators, self-adjoint, isometric and unitary operators on Hilbert spaces

**CO4** explain the concept of the spectrum of a bounded linear operator.

**Unit I:**
**Review of Metric Spaces:** Convergence, Completeness and Baire's theorem. (6 hours)

**Unit II:**
**Banach Spaces:** Definition and some examples, continuous Linear Transformations, The Hahn-Banach theorem, The natural embedding of N in N**, Weak and weak* topology, The open mapping theorem, Uniform boundedness principle. (26 hours)

**Unit III:**
**Hilbert Spaces:** Definition and examples, Orthogonal complements, Orthogonal sets, The conjugate of a Hilbert space, The adjoint operator, Self-adjoint, Normal and unitary operators, Projections, Finite dimensional spectral theorem. (16 hours)

**References:**


1) George F. Simmons - Introduction to topology and Modern Analysis , Krieger Publications, 2003
2) KosakuYosida - Functional Analysis, Springer International, 6th edition, 1995
3) A. E. Taylor - Introduction to functional analysis, John Wiley and sons, 1958
4) Ward Cheney - Analysis for Applied Mathematics , Graduate Texts in Mathematics, 2001
5) Walter Rudin - Real and Complex Analysis , MHHE, 3rd edition,1987

## PS 565.4 Partial Differential Equations

**Course Objectives:**

To study Partial Differential Equations of first and second order.

**Course Outcomes** :

After completing this course, the student will be able to

**CO1** Study surfaces and curves in three-dimension space.

**CO2** Classify partial differential equations and transform into canonical form

**CO3** Solve linear partial differential equations of both first and second order

**CO4** Analyze the origin of first order partial differential equations and solving them using Charpit's method

**CO5** apply partial derivative equation techniques to predict the behavior of certain phenomena.

**Unit I:**

**First Order Partial Differential Equation**: Methods of solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$,

Orthogonal trajectories of a system of curves on a surface, Pfaffian differential forms and Pfaffian differential equations and solutions, Origin of first order partial differential equations, The Cauchy problem for first order equations, Linear equations of first order, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear equations of first order, Cauchy's method of characteristics, Charpit's method, Special types of first order equations, Linear partial differential equations with constant coefficients.

(24 hours)

**Unit II:**

**Second order Partial Differential Equations**: Classification of second order PDE, Canonical forms, Adjoint operators

**Elliptical Differential Equations**: Occurrence of the Laplace and Poisson equations, Boundary value problems, Properties of harmonic functions, Dirichlet problem for a rectangle, Neumann problem for a rectangle

**Parabolic Differential Equations**: Occurrence of the diffusion equation, Elementary solutions of the diffusion equation, Dirac Delta function, Separation of variables.

**Hyperbolic differential Equations**: Solution of one dimensional equation by canonical reduction, Initial value problem – D'Alembert's solution, Vibrating string – variable separation method, Forced vibrations, Boundary and initial value problem for two dimensional wave equation, (24 hours)

References:


1)Ian Sneddon - Elements of Partial Differential Equations, McGraw Hill International Student Edition, 1957

2)K. SankaraRao, Introduction to Partial Differential Equations, Prentice Hall of India, 3rd edition, 2010

3)F. John – Partial Differential Equations, Springer Verlag, New York, 4th edition, 1971.

4)P. Garabedian – Partial Differential Equations, Wiley, New York, 1964.

5)C. R. Chester – Techniques in Partial Differential Equations, McGraw Hill, New York, 1971.

# PS 566.4 Algebraic Number Theory

**Course Objectives:**
This course is concerned with the basics of algebraic number theory. Topics such as congruence, quadratic residues and factorization of ideals in Dedekind domains are covered in this course. Some of the applications of the said concepts are also included.

**Course Outcomes**
A student will be able to

**CO1** Define and interpret the concepts of congruence, and use the theory of congruences in applications.

**CO2** Prove and apply properties of multiplicative functions such as the Euler phi-function and of quadratic residues.

**CO3** Apply the Law of Quadratic Reciprocity and other methods to classify numbers as quadratic residues, and quadratic non-residues

**CO4** To study the number theoretic applications of unique factorization and solving some Diophantine equations

**CO5** Factorization of ideals in Dedekind domains

**Unit I:**
**Introduction:**
Elementary results in number theory, Euler's and Fermat's theorems, The Legendre symbol, Euler's criterion, Gauss lemma, Quadratic reciprocity law. (18 hours)

**Unit II:**
**Number Theoretical Applications of Unique Factorization**:
Algebraic integers, Quadratic Fields, Certain Euclidean rings of algebraic integers, some Diophantine equations (20 hours)

**Unit III:**
**Factorization of Ideals:**
Dedekind domains, Fractional ideals, Invertible ideals, Prime factorization of ideals
(10 hours)

**References:**


1) Karlheinz Spindler - Abstract algebra with Applications, Vol II, Rings and Fields, CRC Press, 1993
2) I. N. Stewart and David Tall - Algebraic Number Theory , Chapman and hall.
3) Jody Esmonde and Rammurthy- Problems in Algebraic Number Theory, Springer Verlag, 2$^{nd}$ edition, 2005
4) I. S. Luthar and I. B. S. Passi - Algebra Vol. II: Rings , Narosa Publishing House, 2012
5) Tom M. Apostal - Introduction to Analytic Number Theory , Springer Verlag, 1976

## PS 567.4 Cryptography

**Course Objectives:**

The purpose of the course is to give a simple account of classical number theory, congruences and to demonstrate applications of number theory and to acquire knowledge on how to deploy encryption techniques to secure data in transit across data Networks.

**Course Outcomes:**

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

**CO1** Have knowledge on fundamentals of number theory.

**CO2** Understand the operations with congruences, linear and non-linear congruence equations.

**CO3** Understand basics of Cryptography and Network Security.

**CO4** Be able to secure a message over insecure channel by various means.

**CO5** Learn about how to maintain the Confidentiality, Integrity and Availability of data.

**CO6** Understand various protocols for network security to protect against the threats in the networks.

**Unit I:**

Some Topics in Elementary Number Theory: Elementary concepts of number theory, Time estimates for doing arithmetic, Divisibility and Euclidian Algorithm, Congruences, Some applications to factoring. (8 Hours)

**Unit II:**

Finite fields and Quadratic residues: Finite fields, Quadratic residues and reciprocity. (12 Hours)

**Unit III:**

Cryptography: Some simple cryptosystems, Enciphering matrices. (13 Hours)

**Unit IV:**

Public Key: The idea of public key cryptography, RSA, Discrete log., Knapsack, Zero- knowledge protocols and oblivious transfer. (15 Hours)

**References:**

1) N. Koblitz - A Course in Number Theory and Cryptography, Graduate texts in Mathematics, No. 114, Springer - Verlag, New York, 1987.
2) A. Baker - A Concise Introduction to Theory of Numbers, Cambridge University Press, 1984
3) A. N. Parshin and I. R. Shafarevich (Eds.) - Number Theory, Encyclopedia of Mathematic Sciences, Vol. 49, Springer -Verlag ,1995.
4) D. R. Stinson - Cryptography: Theory and Practic , CRC Press, 1995.
5) H. C. A. van Tilborg - An Introduction to Cryptography, Springer, 1988.
6) Wade Trappe and Lawrence C. Washington - Introduction to Cryptography with Coding Theory, Prentice Hall, 2nd edition, 2007.

## PS 568.4 Distribution Theory

**Course Objectives**

To study standard and continuous distributions, MGF, Mathematical Expectation, Marginal and conditional distributions, Some Special Distributions.

**Course Outcomes:**

**CO1** Demonstrate the random variables and its functions
**CO2** Infer the expectations for random variable functions and generating functions.
**CO3** Demonstrate various discrete and continuous distributions and their usage
**CO4** Study Marginal and conditional distributions.
**CO5** The Poisson Distribution and The Gamma and Chi-square distributions to solve problems.
**CO6** Study the t & F distributions and their applications.

**Unit I:**

Distribution functions of a random variable, Moment generating function (mgf), Probability generating function. Standard discrete distributions: Uniform, binomial, Poisson, Geometric, Negative binomial, Hyper geometric distribution, mean, variance and mgf of these distributions.

(12 hours)

**Unit II:**

Standard continuous distributions: Normal, Bivariate normal, Lognormal, Exponential, Gamma, Beta, Weibull, Laplace Pareto, Chi square, t and F distributions. Non-Central Chi- square, t and F distribution. (12 hours)

**Unit III:**

Truncated, power series, compound, and mixture distributions. Distributions of functions of random variables: Transformation technique and moment generating function technique.

(12 hours)

**Unit IV:**

Distribution functions of a random vector, Joint, marginal, and conditional distributions, Conditional expectation and conditional variance. Distributions of functions of several random variables - change of variables technique. Convolution of two random variables. (12 hours)

**References:**


1. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. - A First Course in Order Statistics, John Wiley, New York, 2008
2. Dudewicz, E.J. and Mishra, S.N. - Modern Mathematical Statistics, John Wiley, New York, 1988
3. Hogg, R.V. and Tanis, E.A.- Probability and Statistical Inference, Macmillan, New York, 9th edition, 2013
4. Johnson, N.L. and Kotz, S. - Continuous Distributions, Vol. 1 and Vol. 2. Houghton Miffin, New York, 1969
5. Mukhopadhyay, P. Mathematical Statistics, Springer, 2001
6. Rohatgi, V.K. and Saleh, A.K.Md.E - An introduction to Probability and Statistics, John Wiley, New York, 2nd edition, 2008
7. Rao, C.R- Linear Statistical Inference and Its Applications, Wiley Eastern, New York, 2nd edition, 2009

# PS 569.4P Computational Lab -2
# (using FOSS and Problem Working)

**Course Objectives:**

To provide exposure to students to latest tools & technologies in the area of computer science to solve mathematical problems

**Course Outcomes:**

Upon completion of the course student will be able to:

| | |
|---|---|
| **CO1** | understand the usefulness of FOSS in Mathematical computations |
| **CO2** | solve differential equations using FOSS |
| **CO3** | classify second order PDE's |
| **CO4** | Solve problems in complex analysis eff3ectively using FOSS |

Finding complementary function and particular integrals of second and higher order ordinary differential equations
Solving different types of partial differential equations, Classification of second order PDE's into parabola, elliptic and hyperbola.
Solving problems on Cauchy-Riemann equations , Implementation of Milne-Thomson method of constructing analytic functions, Verifying real and imaginary parts of an analytic function being harmonic, Examples connected with Cauchy's integral theorem.

LaTeX - introduction, document preparation

**The above list may be changed annually with the approval of PG Board of Studies in Mathematics.**

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