

**REVISED STRUCTURE WITH INCLUSION OF IKS (1<sup>st</sup> Sem, Paper  
1<sup>st</sup> Unit- V) IN PG MATHEMATICS SYLLABUS AS PER NEP 2020  
GUIDELINES RECEIVED FROM UP GOVERNMENT**

(w.e.f - session 2023-24)

**Course Structure and Syllabus  
Program: M.A./M.Sc. Mathematics  
CSJM University, Kanpur**

**M.A./M.Sc. First Year, Semester-I**

S. No.	Course Code	Credit/Total Marks	Name of the Course	Remark
1.		5/100	Real Analysis	Core paper
2.		5/100	Topology	Core paper
3.		5/100	Advanced Complex Analysis	Core paper
4.		5/100	Dynamics of Rigid Bodies	Core paper
5.		4/100	Introductory Statistical Methods	Minor
6.			Research Project	Project
<b>Total</b>		<b>20/400</b>		

**M.A./M.Sc. First Year, Semester-II**

S. No.	Course Code	Credit/Total Marks	Name of the Course	Remark
1.		5/100	Advanced Real Analysis	Core paper
2.		5/100	Advanced Topology	Core paper
3.		5/100	Operations Research	Core paper
4.		5/100	(I) Mathematical Statistics (II) History and Development of Indian Mathematics (III) Fuzzy Set Theory (IV) Programming in C	Elective paper
5.		8/100	Research Project	Project
<b>Total</b>		<b>28/500</b>		

**M.A./M.Sc. Second Year. Semester-III**

<b>S. No.</b>	<b>Course Code</b>	<b>Credit/Total Marks</b>	<b>Course Name</b>	<b>Remark</b>
1.		4/100	Abstract Algebra	Core paper
2.		4/100	Functional Analysis	Core paper
3.		4/100	Fluid Dynamics	Core paper
4.		4/100	(I) Special Functions (II) Advanced Ordinary Differential Equations (III)Vedic Ganita (IV)Bio-Mechanics	Elective
5.		4/100	Computational Mathematics with Python-I	Practical
6.			Research Project	Project
<b>Total</b>		<b>20/500</b>		

**M.A./M.Sc. Second Year, Semester-IV**

S. No.	Course Code	Credit/Total Marks	Course Name	Remark
1.		4/100	Advanced Abstract Algebra	Core paper
2.		4/100	Integral Equations and Boundary Value Problems	Core paper
3.		4/100	(I) Advanced Fluid Mechanics (II) Wavelet Analysis (III) Theory of Relativity (IV) Differential Geometry of Manifolds (V) Advanced Discrete Mathematics	Elective
4.		4/100	(I) Operator Theory (II) Calculus of Variations (III) Mathematical Modelling (IV) Cosmology (V) Cryptography	Elective
5.		4/100	Computational Mathematics with Python-II	Practical
6.		8/100	Research Project	Project
<b>Total</b>		<b>28/600</b>		

**Note:**

1. There will be a research project of 4 credits in each semester. The student shall submit the research projects done in the 1<sup>st</sup> and 2<sup>nd</sup> semester in the form of a Dissertation at the end of 2<sup>nd</sup> semester. The submitted dissertation will be evaluated by supervisor and an external examiner nominated by the University. The total marks for the dissertation will be 100. The evaluation of research project of semester 3 and 4 will be done at the end of 4<sup>th</sup> semester in the same way as done for the 1<sup>st</sup> and 2<sup>nd</sup> semester at the end of 2<sup>nd</sup> semester.

2. There will be a minor elective of 4 credits/100 marks from other faculty to be taken in 1<sup>st</sup> year (1<sup>st</sup> or 2<sup>nd</sup> semester, only once).

## M.A./M.Sc. First Semester

### Mathematics

#### Paper 1

#### Real Analysis

**Credits: 05**

**Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Real Analysis**

**Course Type: Core paper**

**Course Level: PG**

#### Unit I

Countable and uncountable sets, Cardinal numbers, Schroeder-Bernstein theorem, Definition and existence of Riemann-Stieltjes integral, Properties of integral, Riemann Stieltjes integral as a limit of sums, Mean value theorem for RS-Integrals, Integration and differentiation, Fundamental theorem of integral calculus, Integration of vector valued functions, Rectifiable curves.

#### Unit II

Uniform convergence of sequence and series of functions,  $M_n$ -test, Weierstrass M-test, Abel test, Dirichlet test, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Weierstrass approximation theorem.

#### Unit III

Power series, Radius of convergence, Uniform convergence of power series, Uniqueness theorem for power series, Abel Theorem, Tauber's theorem, Function of bounded variation, Algebra of function of bounded variation, Jordan decomposition theorem, Absolute continuity.

#### Unit IV

Concept of functions of several variables, Euclidian's spaces, Linear transformations, Limit of function, Continuous function, Derivatives in an open subset of  $R^n$ , Chain rule, partial derivatives. Directional derivative, Repeated partial derivatives, Mean value theorem for vector valued functions, Taylor's theorem, Inverse function theorem, Implicit function theorem, Maxima and Minima of a real valued function defined on a subset of  $R^n$

**Unit V.** Contribution of Indian Mathematicians such as -- Sridharacharya, Mahaveeracharya, Shripati, Aryabhata II, Bhaskaracharya II, Contributions of Kerala School as Madhava, Nilkantha.

**Recommended books:**

1. G.F. Simmons, Topology and Modern Analysis, McGraw-Hill Book company.
2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House.
3. B.B.Dutta and A.N singh, History of Hindu Mathematics, 2-Vol. Bharatiya Kala Prakashan, Delhi -2001
4. C.N,Srinivasiengar, The History of Ancient Indian Mathematics, World Press, 1988

5. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill Book company.
6. Parijat Sinha, Real Analysis, Kedarnath Ramnath Publications.

## **Paper 2**

### **Topology**

**Credits: 05**

**Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Topology**

**Course Type: Core paper**

**Course Level: PG**

#### **Unit I**

Set, Continuum hypothesis, Axiom of choice, Zorn's lemma, Well ordering principle.

Topological space: Definition through open set axioms, Examples include usual topology, Ray, Lower limit and upper limit topologies on  $\mathbb{R}$ , Co-finite and co-countable topologies, Weak and strong topologies, The topology of metric spaces, Equivalent metrics, Metrizable spaces, Intersection and union of topologies, Closed sets, Limit points, Derived sets, Adherent points, Dense set, Nowhere dense sets, Perfect sets, Characterization of closed sets in terms of derived sets, The interior of a set, Closure, Exterior, Boundary of a set.

#### **Unit II**

Characterization of topologies in terms of closed sets, Kuratowski's closure axioms and characterization of topology in terms of these.

Neighbourhoods, Neighbourhood system and neighbourhood base, Topology through neighbourhood axioms, Interior operator, Exterior operator, Characterization of topological spaces in terms of these, Base and subbase for topology and characterization of topology in terms of base and subbase axioms, Topology generated by a family of subsets.

#### **Unit III**

First countable and second countable spaces, Relative topology and subspaces, Hereditary property, Lindelof theorem and separable spaces, Continuous functions and their properties, Continuity in terms of open sets, closed sets, neighbourhoods and closures, Convergence of a sequence, Sequential continuity, Open mapping, Homeomorphisms, Topological invariant properties.

#### **Unit IV**

Separation axioms-  $T_0$ ,  $T_1$ ,  $T_2$ , Regular,  $T_3$ , Normal and  $T_4$  spaces, Their comparison and examples, Hereditary and Topological invariant characteristics, Completely regular space, Tychonoff space, Completely normal spaces, Urysohn's lemma and Tietze extension theorem.

**Recommended books:**

1. George F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw-Hill Book Company (1963).
2. J. L. Kelley, General Topology, Van Nostrand, Reinhold Co., New York (1995).
3. K. D. Joshi, Introduction to General Topology, Wiley Eastern Ltd. (1983).
4. James R. Munkres, Topology, Prentice Hall of India Pvt. Ltd., New Delhi (2000).
5. S. Willard, General Topology Addison-Wesley, Reading, 1970.
6. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).

**Paper 3**  
**Advanced Complex Analysis**

**Credits: 05****Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Advanced Complex Analysis****Course Type: Core paper****Course Level: PG****Unit I**

Stereographic projection, Branch point, Branch cut, Branches of multi-valued functions with special reference to  $\arg z$ ,  $\log z$  and  $z^a$ , Morera's theorem, Cauchy's inequality, Maximum and minimum modulus principle, Schwarz's lemma, Open mapping theorem, Meromorphic functions.

**Unit II**

Zeros of analytic functions, Singularities and their classification, Residues, Argument principle, Rouché's theorem, Evaluation of real integrals, Linear and bilinear transformations, Fixed points, Cross ratio, Inverse points and critical points, Conformal transformations involving straight lines, circles and half-planes.

**Unit III**

Weierstrass' factorization theorem, Gamma function and its properties, Riemann zeta function, Mittag-Leffler's theorem, Analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Natural boundary, Schwarz's reflection principle.

#### **Unit IV**

Harmonic functions on a disk, Harnack's inequality and theorem, Canonical products, Jensen's formula, Hadamard's three circle theorem, Entire functions, Order of an entire function, Exponent of convergence, Univalent functions, Bieberbach's theorem (statement only) and  $\frac{1}{4}$  theorem, Convex functions and its properties.

#### **Recommended books:**

1. Complex Variables with an Introduction to Conformal Mapping and its Applications, Schaum's Outlines, McGraw-Hill, 2009.
2. John B. Conway, Functions of One Complex Variable, Springer.
3. Walter Rudin, Real and Complex Analysis, McGraw-Hill Co., 1966.
4. H. S. Kasana, Complex Variables: Theory and Applications, PHI Learning.
5. S. Ponnusamy, Foundations of Complex Analysis, Narosa Pub.
6. R. V. Churchill & J. W. Brown, Complex Variables and Applications, 5<sup>th</sup> Edition, McGraw-Hill, New York, 1990.
7. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand & Co., New Delhi.

### **Paper 4 Dynamics of Rigid Bodies**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Dynamics of Rigid Bodies**

**Course Type: Core paper**

**Course Level: PG**

#### **Unit I**

Moments and product of inertia with examples, Use of Routh's rule, Radius of gyration, Momental ellipsoid and ellipse, Principal axes, Equipmental system.

#### **Unit II**

D'Alembert's principle, General equation of motion. Motion of the centre of inertia, Application of D'Alembert's principle to general equation of motion, Motion about fixed axis, Compound pendulum, Simple equivalent pendulum, Centre of percussion.

#### **Unit III**

Generalised coordinates. Degrees of freedom, Classification of mechanical systems, Generalized velocities, forces, kinetic energy, Lagrangian equations by D'Alembert's principle, Lagrangian function. Principle of conservation of energy.

## Unit IV

Hamilton's principle, Hamilton's equation of motion and Hamiltonian function, Physical significance of the Hamiltonian, Derivation of Lagrange's equation by Hamilton's principle, Principle of least action, Deduction of Lagrange's equations using Hamilton's principle, Euler's dynamical equations, Kinetic energy, Euler's geometrical equations, Deduction of Euler's equations from Lagrange's equation, Deduction of Euler's equations from Hamilton's equation.

### Recommended books:

1. Classical mechanics by J.C. Upadhyaya, Himalaya Publishing House Pvt. Ltd.
2. Principles of Engineering Mechanics, Vol 2 by Millard F. Beatty, Jr, Springer International Edition.
3. Classical mechanics by H. Goldstein, 2nd edition, Narosa Publishing House.
4. Classical Mechanics by Gupta, Kumar and Sharma.
5. Dynamics of Rigid Bodies by B.D. Sharma, B.S. Tyagi, Brahma Nand, Kedar Nath Ram Nath Publishers, India.

Online Source 1. <http://math.ucr.edu/home/baez/classical/texfiles/2005/book/classical.pdf>

2. [http://courses.physics.ucsd.edu/2010/Fall/physics200a/LECTURES/200\\_CO URSE.pdf](http://courses.physics.ucsd.edu/2010/Fall/physics200a/LECTURES/200_CO URSE.pdf)

## Paper 5 (Minor) Introductory Statistical Methods

**Credits: 04**

**Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Introductory Statistical Methods**

**Course Type: Minor**

**Course Level: PG**

### Unit I

Measures of central tendency, Frequency distribution, Graphical representation of frequency distribution, Properties of measures of central tendencies, Probability and examples of probability, Conditional probability, Discrete probability distributions (Binomial and Poisson), Continuous probability distributions (Normal).

### Unit II

Dispersion, Various measures of dispersion, Minimal property of mean deviation, Root mean square deviation, Variance and standard deviation.

Moments about mean, origin, and any point, Skewness, Kurtosis, Pearson's  $\beta$  and  $\gamma$ -coefficients, Method of least squares, Curve fitting, Fitting of straight lines, Fitting of second-degree curve, Fitting of a polynomial of k-th degree, Change of origin, Selection of type of curve to be fitted, Exponential curves.

### **Unit III**

Correlation and Regression Analysis: Significance of measuring correlation, Types of correlation, Methods of measuring correlation, Regression analysis, Lines of regression.

### **Unit IV**

Sampling and Hypothesis Testing: Census and sampling method, Merits and limitations of sampling, Sampling and non-sampling errors, Reliability of samples, Standard error of estimate.

t- test for single mean and difference of means, F-test, z-test, Chi-square test.

### **Recommended books:**

1. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
2. Goon A. M., Gupta M. K. and Dasgupta B. (2005): Fundamentals of Statistics, Vol. I, 8th Ed., World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V. K. (2007): Fundamentals of Mathematical Statistics, 11th Edn., (Reprint), Sultan Chand and Sons.
4. Mood, A. M. Graybill, F. A. and Boes, D. C. (2007): Introduction to the Theory of statistics, 3<sup>rd</sup>Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
5. Hogg, R.V. and Tanis, E. A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.

## **M.A./M.Sc. Second Semester**

### **Mathematics**

### **Paper 1**

### **Advanced Real Analysis**

**Credits: 05**

**Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Advanced Real Analysis**

**Course Type: Core paper**

**Course Level: PG**

## Unit I

Algebra of sets, Borel sets,  $F_\sigma$  and  $G_\delta$  set, Measure, Finite and  $\sigma$  finite measure, Complete measure, Regularity of a measure, Lebesgue outer measure, Lebesgue measure, Measurable sets.

## Unit II

Measurable functions, Egoroff's theorem, Borel and Lebesgue measurability, Convergence in measure.

## Unit III

Lebesgue integral of a bounded function, The general Lebesgue integral, Riemann and Lebesgue integrals, Lebesgue bounded convergence theorem, Integration of non-negative measurable functions, Fatou lemma, Lebesgue monotone convergence theorem, Integrable functions, Lebesgue integral of unbounded function, Lebesgue dominated convergence theorem.

## Unit IV

The  $L^p$  Spaces, Convex functions, Jensen's inequality, Holder and Minkowski inequalities, Riesz Fischer theorem, Convergence in measure, Almost uniform convergence

Signed measure, Positive and negative sets, Hahn-decomposition theorem, Jordan-decomposition theorem, Radon-Nikodym theorem.

### Recommended books:

1. G. de Barra, Measure theory and Integration, New age International (P) Limited publishers
2. H. L. Royden, Real Analysis, Pearson Education Pvt. Ltd.
3. P. R. Halmos, Measure theory, D Van Nostrand company.
4. Parijat Sinha, Real Analysis, Kedarnath Ramnath Publications.

## Paper 2 Advanced Topology

**Credits: 05**

**Max. Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Advanced Topology**

**Course Type: Core paper**

**Course Level: PG**

## **Unit I**

Compact sets and their properties, Finite intersection property, Bolzano Weierstrass property, Continuous functions and compactness, Sequential compactness, Countable compactness and their comparison, Locally compact spaces and compactness in real line,  $\epsilon$ -net, totally bounded sets, Lebesgue numbers for covers, Lebesgue covering lemma, One point compactification.

## **Unit II**

Separated sets, Connectedness in terms of separated sets, Characterization of connected sets in terms of open sets and closed sets, Closure of a connected set, Union of connected sets, Connected sets in  $\mathbb{R}$ , Continuity of a function and connectedness, Components and partition of space, Locally connected sets, Totally disconnected sets.

## **Unit III**

Nets and Filters: Directed sets, Residual subset, Cofinal subset, Nets and subnets and their examples, Convergence of a net, Characterisation of open sets, closed sets, closure, cluster point and limit point of a set in terms of net convergence, Hausdorffness and continuity of a function in terms of nets.

Definition of filter and its examples, Free and fixed filters, Discrete and indiscrete filters, Neighbourhood filter, Comparison of filters, Filter base and convergence of a filter, Ultrafilters, Continuous functions and filters, Net based on filter and filter based on net.

## **Unit IV**

Quotient topology, Quotient space  $X/R$ , Finite product space, Projection mapping, Tychonoff product topology in terms of standard subbase and its characterizations in terms of projection maps, Continuous functions, Product of  $T_0$ ,  $T_1$ ,  $T_2$ , spaces, Connectedness and compactness, First and second countability for product spaces.

### **Recommended books:**

1. George F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw-Hill Book Company (1963).
2. J. L. Kelley, General Topology, Van Nostrand, Reinhold Co., New York (1995).
3. K. D. Joshi, Introduction to General Topology, Wiley Eastern Ltd. (1983).
4. James R. Munkres, Topology, Prentice Hall of India Pvt. Ltd., New Delhi (2000).
5. S. Willard, General Topology Addison-Wesley, Reading, 1970.
6. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).

## **Paper 3**

### **Operations Research**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Operations research**

**Course Type: Core paper**

**Course Level: PG**

#### **Unit I**

History and development of operations research, Operations research and its scope, necessity of operations research in industry and management, Role of operations research in decision-making, Development of operations research in India, Job sequencing, Convex set and their Application.

#### **Unit II**

Linear Programming: Simplex method, Theory of simplex method, Duality and sensitivity analysis. Integer programming: Branch and bound technique, Transportation and assignment problems.

#### **Unit III**

Game theory: Two-person, zero-sum games, Games with mixed strategies, Principle of dominance, Solution of 2x2 games without saddle point, Graphical solution, Solution by linear programming.

Dynamic Programming: Deterministic and probabilistic dynamic programming.

#### **Unit IV**

Network Analysis: Shortest path problem, Minimum spanning tree problem, Maximum flow problem, Minimum cost flow problem, Project planning and control with PERT-CPM.

Non-linear Programming: One and multi-variable unconstrained optimisation, Kuhn-Tucker conditions for constrained optimisation, Quadratic programming.

#### **Recommended books:**

1. Kanti Swarup, P. K. Gupta and Manmohan: Operations Research, S. Chand and Co.
2. H.A. Taha: Operations Research-An introduction, Macmillan Publishing Co. Inc., New York.
3. P. K. Gupta and D. S. Hira: Operations Research-An introduction, S. Chand and Co. Ltd. New Delhi.

## **Paper 4(I)**

### **Mathematical Statistics**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Mathematical Statistics**

**Course Type: Elective paper**

**Course Level: PG**

#### **Unit I**

Random variable, Probability mass function, Probability density function, Cumulative distribution function, Two and higher dimensional random variables, Joint distribution, Marginal and conditional distributions, Stochastic independence, Function of random variables and their probability density functions.

Discrete probability distributions: Binomial, Poisson, Geometric, Hyper geometric multinomial. Continuous probability distributions: Exponential, Gamma, Beta, Normal distributions.

#### **Unit II**

Mathematical expectations and moments, Moment generating function and its properties, Chebyshev's inequality and its application, Stochastic convergence, Central limit theorem, Partial and Multiple correlation coefficients, Correlation ratio, Association of attributes.

#### **Unit III**

Sampling Distributions: Chi-square, t and F-distributions with their properties, Distribution of sample mean and variance, Distribution of order statistics and sample range from continuous populations.

Applications of Sampling Distributions: Test of mean and variance in the normal distribution, Tests of single proportion and equality of two proportions, Chi-square test, t-test, F-test.

#### **Unit IV**

Testing of Hypothesis: Null hypothesis and its test of significance, Simple and composite hypothesis, MP test, UMP test, Likelihood tests (excluding properties of likelihood ratio tests).

Point Estimation: Estimators, Properties of estimators, Unbiasedness, Consistency, Sufficiency, Efficiency.

#### **Recommended books:**

1. Hogg R.V., Mckean, J. W. and Craig A. T.: Introduction of Mathematical Statistics, Seventh Edition (2013) Pearson India.
2. Hoel P. G: Introduction to Mathematical Statistics, Fourth Edition ((1971), John Wiley & sons.
3. Gupta S. C.and Kapoor V. K.: Fundamentals of Mathematical Statistics, (2019) Kedarnath Ramnath pub., Meerut India

4. Mukhopadhyay, P. : Mathematical Statistics, (2016) Books and Allied Publications.
5. Goon, A. M., Gupta M. K. & Das Gupta B.: Fundamental of statistics, Vol. I, (2005), 8<sup>th</sup> Edition World Press, Kolkata.

**Paper 4(II)**  
**History and Development of Indian Mathematics**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: History and Development of Indian Mathematics**

**Course Type: Elective paper**

**Course Level: PG**

**Unit I**

Indian contributions to decimal system and place value, The mathematical sophistication of the Harappan culture, The Vedic period and the sulva geometry.

**Unit II**

Contribution of the Jainas, Chandas Sutras of Pingala and binary arithmetic, The Baksali Manuscript, Aryabhata I, Varahamihir, Brahmagupta, Bhaskara I.

**Unit III**

Sridharacharya, Mahaveeracharya, Shripati, Aryabhata II, Bhaskaracharya II, Contributions of Kerala school as Madhava, Nilkantha.

**Unit IV**

Srinivasa Ramanujan, Swami Bharati Krishna Tirthaji, Prasanta Chandra Mahalanobis, Prof. Harishchandra.

**Recommended books:**

1. B. B. Datta and A. N. Singh, History of Hindu Mathematics, 2 Volumes, Bharatiya Kala Prakashan, Delhi, 2001.
2. C. N. Srinivasiengar, The history of Ancient Indian mathematics, World Press, 1988.

**Paper 4(III)**  
**Fuzzy Set Theory**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Fuzzy Set Theory**

**Course Type: Elective paper**

## **Course Level: PG**

### **Unit I**

Fuzzy Sets: Basic definitions,  $\alpha$ -level sets, Convex fuzzy sets, Basic operations on fuzzy sets, Types of fuzzy sets, Cartesian products. Algebraic products, Bounded sum and difference, t-norms and t-conorms.

### **Unit II**

The Extension Principle: The elements of fuzzy arithmetic, Zadeh's extension principle, Image and inverse image of fuzzy sets, Fuzzy numbers.

### **Unit III**

Fuzzy Relations and Fuzzy Graphs: Fuzzy relations on fuzzy sets, Composition of fuzzy relations, Min-Max composition and its properties, Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy relation equations, Fuzzy graphs, Similarity relation.

### **Unit IV**

Possibility Theory: Fuzzy measures, Evidence theory, Necessity measure, Possibility measure, Possibility distribution, Possibility theory and Fuzzy sets, Possibility theory versus probability theory.

### **Recommended books:**

1. Klir, G. J. and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India, New Delhi 1995
2. Zimmermann, H. J., Fuzzy Set Theory and Its Applications, Allied Publishers Ltd, New Delhi 1991
3. Ross, T. J., Fuzzy Logic with Engineering Applications, McGraw Hill Inc., New Delhi
4. Backzinski, M. and J Balasubramanian, Fuzzy Implications, Springer Verlag, Heidelberg 2008.

## **Paper 4(IV) Programming in C**

**Credits: 05**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment - 25 marks  
Semester End Examination - 75 marks

**Course Title: Programming in C**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Overview of C: History and importance of C, Sample Programs, Programming Style, Executing a 'C' programme, Constants, Variables and data type.

Operators: Arithmetic, Relational, Logical, Assignment, Increment and Decrement, Conditional, Bitwise, Special. Expressions: Arithmetic expressions, evaluation of expressions, Input and output operators.

## **Unit 2**

Decision Making and Branching: Decision making with if statement, simple if statement, the if-else statement, Nesting of if-else statements, The else if Ladder, The Switch statement, The Goto statement.

## **Unit 3**

Decision Making and Looping: The while statement, The do statement, The for statement, Jump in Loop.

Arrays: One and two-dimensional arrays, Declaration of one and two-dimensional arrays, Initializing of one and two-dimensional arrays, Multi-dimensional arrays, Dynamic arrays, Character arrays and strings.

## **Unit 4**

User-defined Functions: Need for user-defined functions, A multi-function program, Elements of user-defined functions, Definition of functions, Functions call, Functions declaration, Category of function, Nesting of functions.

Pointers: Understanding pointers, Declaring pointer variables, Initializing of pointer variables, Accessing a variable through its pointer, Chain of pointers, Pointers and arrays, Pointer as a function argument, File management in C.

### **Recommended books:**

1. E. Balagurusamy: Programming in ANSI C, MacGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Yashavant Kanetkar, Let us C, BPB Publications, India.

## **M.A. /M.Sc. Third Semester**

### **Mathematics**

### **Paper 1**

### **Abstract Algebra**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Abstract Algebra**

**Course Type: Core paper**

**Course Level: PG**

**Unit I**

Internal and external direct product of groups and their relationship, Normal and sub normal series of groups, Composition series, Zassenhaus lemma, Schreier theorem, Jordan Holder theorem.

**Unit II**

Commutator subgroup and commutator series of a group, Solvable groups, Solvability of subgroups and factor groups and of finite  $p$  groups, Lower and upper central series, Nilpotent groups.

**Unit III**

Cauchy theorems, Action of a group  $G$  on a set, Stabilizer subgroups and orbit decomposition, Class equation of an action, Sylow subgroups, Sylow's theorem I, II and III,  $p$ -groups, Examples and applications, Groups of order  $p.q$ , Direct and inverse images of Sylow subgroups, Structure theorem for finite abelian groups.

**Unit IV**

Canonical forms, Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, Index of nilpotency, Invariants of a nilpotent transformation, The primary decomposition theorem, Jordan blocks and Jordan canonical forms.

**Recommended books:**

1. I. N. Herstein, Topics in Algebra, Wiley student edition
2. Ram Ji Lal, Algebra I and Algebra II, Springer
3. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publications
4. John B. Fraleigh, A First Course in Abstract Algebra, Narosa Publications
5. Vijay K. Khanna, S.K Bhambri, A Course in Abstract Algebra
6. S. Lipschutz, Linear Algebra, Schaum's Outline Series.

**per 2**

**Functional Analysis**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Functional Analysis**

**Course Type: Core paper**

**Course Level: PG**

## **Unit I**

Normed linear spaces, Examples of normed linear spaces and its topological properties, Cauchy's inequality, Hölder's and Minkowski's inequality, Convergence in normed linear spaces, Cauchy sequence, Banach space, Examples of Banach space, Quotient space of normed linear space, Equivalent norms, Riesz lemma.

## **Unit II**

Continuous linear transformation, Bounded linear transformations, Norm of bounded linear transformation, Space of bounded linear transformations. Conjugate space (dual space), Functional, Hahn-Banach theorem for real and complex normed linear spaces, Applications of Hahn-Banach theorem, The natural embedding.

## **Unit III**

Open mapping theorem, Projection of Banach space, Closed graph theorem, Baire category theorem, Uniform boundedness principle.

Inner product spaces, Hilbert spaces with examples, Cauchy-Schwarz's inequality.

## **Unit IV**

Orthogonal complement, Orthonormal set and its existence, Bessel's inequality, Complete orthonormal sets and its characterization. Continuous linear functional on Hilbert space, Riesz representation theorem, Reflexivity of Hilbert space. Weak and strong convergence.

### **Recommended books:**

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
2. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, New Delhi, 2002.
3. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1966.
4. B. V. Limaye, Functional Analysis, Wiley Eastern Ltd.
5. N. Saran and S. L. Shukla, Functional Analysis, Pragati Prakashan, Meerut.
6. P. K. Jain, O. P. Ahuja and K. Ahmad, Functional Analysis, New Age International (P) Ltd. And Wiley Eastern Ltd., New Delhi, 1997.
7. B. Choudhary and S. Nanda, Functional Analysis with Applications, Wiley Eastern Ltd., 1989.
8. J. N. Sharma and A. R. Vasishtha, Functional Analysis, Krishna Prakashan Media (P) Ltd., 2015.

**Paper 3**  
**Fluid Dynamics**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Fluid Dynamics**

**Course Type: Core paper**

**Course Level: PG**

**Unit I**

Types of fluids, Continuum hypothesis, Lagrangian and Eulerian method of describing fluid motion, Equation of continuity in cartesian, Cylindrical polar, Spherical polar and Orthogonal curvilinear coordinates, Vorticity vector, Velocity potential, Stream lines, Path lines and streak lines, Rotational and irrotational motion of fluid, Boundary surface and boundary condition.

**Unit II**

Euler's equation of motion: conservation of momentum, Bernoulli's equation, Lagrange's equation of motion, Energy equation, Impulsive effects, Helmholtz's vorticity theorem and vorticity equation, Applications of Bernoulli's equation.

**Unit III**

Two dimensional irrotational motion, Stream or current function, Physical significance of stream function, sources, sinks, doublets and their images in two-dimension, Complex potential, The Milne-Thomson circle theorem, Theorem of Blasius, Flow and circulation, Kelvin's circulation theorem, Permanence of irrotational motion, Kelvin's Minimum Kinetic Energy theorem.

**Unit IV**

Motion of cylinders: General motion of cylinder in two dimensions, Kinetic energy, Motion of circular, coaxial and elliptic cylinders, Streaming past and circulation for a fixed circular and elliptic cylinder, Kinetic energy of rotating elliptic cylinder, The aerofoil.

**Recommended books:**

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydrodynamics, CBS publishers and Distributors, Delhi, 1988.
2. R.K. Rathy, An introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi; 1976.
3. F. Charlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S.W. Yuan, Foundations of Fluid Dynamics, Prentice – Hall of India, 1988.

**Paper 4(i)****Special Functions****Credits: 04****Max Marks:100****Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Special Functions****Course Type: Elective paper****Course Level: PG****Unit I**

Absolute and uniform convergence of infinite products, The Weierstrass's infinite product and Euler's integral for Gamma function and their equivalence, Beta function, Factorial function, Legendre's duplication formula, Gauss' multiplication theorem, Orthogonal sets of functions, orthogonal sets of polynomials, Gram-Schmidt process of orthonormalization.

**Unit II**

Hypergeometric function, Integral representation of hypergeometric function and deductions from it, Contiguous function relations, Relations between hypergeometric functions of  $z$  and  $1 - z$ , Simple and quadratic transformations of hypergeometric function.

**Unit III**

Generalised and confluent hypergeometric function, Formation and solution of differential equation for generalised and confluent hypergeometric function and their contiguous function relations, Saalschutz theorems, Whipple's theorems and Dixon's theorem, Contour integrals of Barnes' type, Hypergeometric forms of Legendre's polynomials.

**Unit IV**

Doubly periodic functions, Elliptic functions and their properties, Weierstrass elliptic function and its differential equation, Theta functions, Properties of theta functions, Relations involving theta functions and differential equations satisfied by theta functions.

**Recommended books:**

1. E. D. Rainville: Special Functions, Chelsea Publishing Co., 1971.
2. N. Saran, S. D. Sharma & T. N. Triuedi: Special Functions, PragatiPrakashan, Meerut.
3. M. A. Pathan, V. B. L. Chaurasia, P. K. Banerji & M. C. Goyal : Special Functions and Calculus of Variations, Indus Valley Publications, New Delhi, 2004.
4. Special Functions, Dr. Vinod Kumar, Epsilon Publishing House Pvt. Ltd., Kanpur, 2020.

**Paper 4(ii)****Advanced Ordinary differential equations****Credits: 04****Max Marks: 100****Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Advanced Ordinary differential equations****Course Type: Elective paper****Course Level: PG****Unit I**

Linear differential equations with constant as well as a variable coefficient, Linear dependence and independence of solutions, Wronskian, Method of undetermined coefficients, Reduction of the order, Initial value problem and equivalent integral equation.

**Unit II**

Picard's iteration method, Lipschitz condition, Existence and uniqueness theorem, An orthogonal set of functions, Boundary value problem, Sturm Liouville problem, Green's functions, Ascoli-Arzela theorems, A theorem on convergence of solutions of a family of initial value problems.

**Unit III**

Linear systems, Matrix method for homogeneous first order system of linear differential equations, Fundamental set of solutions, Fundamental matrix of solutions, Wronskian of solutions, Basic theory of the homogeneous linear system, Abel-Liouville formula, Nonhomogeneous linear system, Sturm theory, Self-adjoint equations of the second order, Abel formula, Sturm separation theorem, Sturm fundamental comparison theorem.

**Unit IV**

Nonlinear differential systems, Phase plane, Path, Critical points, Autonomous systems, Isolated critical points, Path approaching a critical point, Path entering a critical point, Types of critical points- Center, Saddle points, Spiral points, Node points, Stability of critical points,

Asymptotically stable points, Unstable points, Critical points and paths of linear systems, Almost linear systems, Nonlinear conservative dynamical system, Dependence on a parameter, Liapunov direct method, Limit cycles, Periodic solutions, Bendixson nonexistence criterion, Poincare-Bendixson theorem(statement only), Index of a critical point.

**Recommended books:**

1. Coddington, E. A., Levinson, N., Theory of ordinary differential equations, Tata McGraw Hill, 2000.
2. Ross, S. L., Differential equations, John Wiley and Sons Inc., New York, 1984.
3. Boyce, W. E., Diprima, R. C., Elementary differential equations and boundary value problems, John Wiley and Sons, Inc., New York, 4th edition, 1986.
4. Simmon, G. F., Differential Equations, Tata McGraw Hill, New Delhi, 1993.

**Paper 4(iii)**

**Vedic Ganita**

**Credits: 04**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Vedic Ganita**

**Course Type: Elective paper**

**Course Level: PG**

**Unit I**

History of Vedic Ganita, Why Vedic Ganita, Silent features of Vedic Ganita, Vedic Ganita formulas, 16 sutras, 13 sub sutras, Terms and operations, High speed addition by using the concept of computing the whole and from left to right, Superfast subtraction by Nikhilamsutram from basis 100, 1,000, 10,000.

**Unit II**

Multiplication by Urdhavtrigbhyam sutram, Multiplication by vinculum sutram, Multiplication by Nikhila sutram, Fast multiplication by 11, Multiplication of numbers consisting of all 9s, Multiplication of numbers nearest to the base 10 and multiplication of numbers with sub base 50,500,5000.

**Unit III**

Meaning of Ekadhiken sutram and its applications in finding squaring of numbers ending in 5, squares by Anurupeyana sutram, Square by Yavdunam thava dunikritya vargamcha yojyet sutram, Squaring by Dwandvayoga sutram, Squaring numbers nearest 50, Square roots of perfect square, General method of square roots, Cubes by Anurupeyana sutram.

## **Unit IV**

Decimal and fractions, Division by Nikhilaṃ Sūtram, Division of  $1/19$ ,  $1/29$  by Ekadhikēnpurven sūtram, Division by Paravartya sūtram, Division by Anurupeyana sūtram, Division of polynomials, Factors of general second-degree equation by Lopsthapanabhyam sūtram.

### **Recommended books:**

1. Vedic Mathematics, published by Motilal Banarasi Das 1965. ISBN 81-2 08-0163-6.
2. Vedic Ganita: Vihangam Drishti-1, Shiksha Sanskriti Utthan Nyasa, New Delhi

## **Paper 4(IV)**

### **Bio-Mechanics**

**Credits: 04**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Bio-Mechanics**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Introduction, Definition and scope of Bio-Mechanics, Role of mathematics in bio-sciences, Basic concepts of fluid dynamics: Navier-Stoke's equation for flow of a viscous incompressible flow, Bio-fluid flows: flows in pipes and ducts, Poiseuille's flow, Application of Poiseuille's law for the study of blood flow.

### **Unit II**

Basic concepts about blood, Cardiovascular system and blood flows, Blood flow through artery with mild stenosis, Two-layered flow in a tube with mild stenosis, Pulsatile flow of blood, Peristaltic flow in tubes and channels.

### **Unit III**

Gas exchange and air flow in lungs, Consumption and transport of oxygen, Weibel's model for flows in lung airways, Comparison between flows of blood and flows in lung airways.

### **Unit IV**

Diffusion, Fick's laws of diffusion, Diffusion equation, Modification of the diffusion equation, Diffusion in artificial kidney, Hemodialyser. Types of hemodialyser.

### **Recommended books:**

1. J. N. Kapur: Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.
2. Y. C. Fung: Bio-Mechanics, Springer-Verlag New York Inc., 1990.
3. Stanley E. Charm and George S. Kurland: Blood Flow and Micro circulation, John Wiley & Sons, 1974.
4. S. A. Levin: Frontiers in Mathematical Biology, Springer-Verlag, 1994.
5. S. K. Pundir & R. Pundir: Biomathematics, Pragati Prakashan, 2010.

## **Paper 5**

### **Computational Mathematics with Python-I**

**Credits: 04**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Computational Mathematics with Python-I**

**Course Type: Practical**

**Course Level: PG**

Python introduction, Technical strength of Python, Introduction to Python interpreter and program execution, Using comments, Installation of Python, Ways to run Python programmes, Simple input and output, Variable and assignments.

Literals, Constants, Numbers (Integers, Floats, Complex Numbers, Real, Sets), Strings (Slicing, Indexing, Concatenation, other operations on strings), Accepting input from console, printing statements, Simple 'Python' programs, Mathematical operators, Permutation and combination. Python as an advanced calculator.

Relational, Logical, Bitwise operators and their precedence, Conditional statements: if, if-else, if-elif-else, Simple programs, Notion of iterative computation and control flow-range function.

While statement, For loop, Break statement, Continue statement, Pass statement, else, assert.

### **Suggested List of programmes:**

1. Programme to obtain three numbers and print their sum.
2. Programme to obtain the length and breadth of a rectangle and calculate its area.
3. Programme to input a number and print its cube.
4. Programme to input a value in kilometre and convert it into miles. (1 Km = 0.621374 miles)
5. Programme to input a value in tonnes and convert it into quintals and kilogram (1 Ton = 10 quintals = 1000 Kg).

6. Write a programme to input two numbers and swap them.
7. Write a programme to input three numbers: 1<sup>st</sup> number becomes 2<sup>nd</sup> number; 2<sup>nd</sup> number become 3<sup>rd</sup> number and 3<sup>rd</sup> number becomes 1<sup>st</sup> number.
8. Write a programme to enter two integers and perform all arithmetic operations on them.
9. Write a programme to obtain temperature in Celsius and convert it into Fahrenheit.
10. Write a programme to input three numbers: 2<sup>nd</sup> number gets the value 1<sup>st</sup> + 2<sup>nd</sup>, 3<sup>rd</sup> number gets the value of 2<sup>nd</sup> + 3<sup>rd</sup> number
11. Programme to find the roots of quadratic equation.
12. Programme that takes a number and check whether the given number is odd or even.
13. Programme to accept three integers and print the largest of three. Make use of only if statement.
14. Programme that input three numbers and calculate two sums as per this:  
Sum1: as the sum of all input numbers  
Sum2: as the sum of non-duplicate numbers; If there are duplicate number in the input, ignore them
15. Programme to test the divisibility of a number with another number.
16. Programme that reads three numbers and print them in ascending orders.
17. Programme to print table of a number, say 7.
18. Programme to print sum of natural number between any two positive number.
19. Programme to calculate the factorial of a number.
20. Programme to calculate the sum of even and odd integers of first n natural numbers.
21. Programme to implement 'guess the number' game. Python generates a number randomly in the range [10,50]. The user is given five chances to guess a number in the range.
22. Write a programme to illustrate the difference between break and continue statements.
23. Programme to input a number and test if it is a prime number.
24. Programme that searches for prime number from 15 through 25.
25. Write a programme to input three numbers and display the largest/smallest number.
26. Write a programme to input a 6-digit number and divide it into 2 digits number.
27. Write a programme to input a number and then print its first and last digit raised to the length of the number.
28. Write a programme to find lowest and second lowest number from the 10 numbers input.
29. Write a programme to print Fibonacci series.

30. Write a programme to read an integer  $>1000$  and reverse the number.

31. Write a programme to find the sum of the series:  $s = 1 + x + x^2 + x^3 \cdots x^n$

32. Write a programme to find the sum of the series:  $s = 1 - x + x^2 - x^3 + x^4 \cdots x^n$

33. Write a programme to find the sum of the series:  $s = x + \frac{x^2}{2!} - \frac{x^3}{3!} + \frac{x^4}{4!} \cdots \frac{x^n}{n!}$ .

34. If a number is equal to the sum the cubes of its each digit, then it is known as Armstrong Number. Write a programme to check if a given number is an Armstrong Number or not.

35. A number is known as palindrome number if it is same as reversed of it. Write a programme to check if a given number is palindrome number or not.

#### **Recommended books:**

1. Core Python programming, Dr. R. Nageshwara Rao, Dreamtech Press.
2. Learning with Python, Allen Downney, Jeffrey Elkner and Chris Meyers, Dreamtech Press.
3. Let Us Python, Aditya Kanetkar and Yashwant Kanetkar, BPB Publication.
4. The new python programming for beginners, William J Palmer, Caterina Rosse.
5. Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More!, Amit Saha, No Starch Press.
6. Mathematics and Python Programming, J. C. Bautista, Lulu Press.

### **M.A. /M.Sc. Fourth Semester**

#### **Mathematics**

#### **Paper 1**

#### **Advanced Abstract Algebra**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Advanced Abstract Algebra**

**Course Type: Core paper**

**Course Level: PG**

#### **Unit I**

Field theory, Extension fields, Minimal polynomial of an algebraic element, Algebraic and transcendental extensions, Splitting fields, Primitive elements, Separable and inseparable extensions, Perfect fields.

## **Unit II**

Automorphisms of fields, Fixed fields, Normal extensions, Galois extensions, Fundamental theorem of Galois theory, algebraically closed fields, Prime fields, Finite fields.

## **Unit III**

Solution of polynomial equations by radicals, Constructible numbers.

Modules, Direct product of modules, Cyclic modules, Sub modules, quotient modules, Fundamental theorem of homomorphism of modules.

## **Unit IV**

Free Modules, Simple modules, Semi-simple modules, Schur's lemma, Noetherian and Artinian modules and rings, Hilbert basis theorem, Wedderburn-Artin theorem, Uniform modules, Primary modules, Noether-Lasker theorem.

### **Recommended books:**

1. I.N. Herstein, Topics in Algebra, Wiley student edition
2. Ram Ji Lal, Algebra I and Algebra II, Springer
3. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publications
4. John B. Fraleigh, A First Course in Abstract Algebra, Narosa Publications
5. Vijay K. Khanna, S.K Bhambri, A Course in Abstract Algebra, Vikas Publishing House
6. Bhattacharya, Jain and Nagpaul, Basic Abstract Algebra, Cambridge University Press

## **Paper 2**

### **Integral Equations and Boundary Value Problems**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Integral Equations and Boundary Value Problems**

**Course Type: Core paper**

**Course Level: PG**

## **Unit I**

Definition of integral equations, Types of integral equations, Kernel, Fredholm and Volterra integral equations, Verification of solution of integral equation, Conversion of integral equation to differential equation and vice-versa, Initial value problem & Volterra integral equation, Boundary value problem and Fredholm integral equation.

## Unit II

Solution of Fredholm integral equation by method of successive approximation, Resolvent kernel, Solution of Fredholm integral equation by method of resolvent kernel, Solution of Volterra integral equation by method of successive approximation, Solution of Volterra integral equation by method of successive substitution, Fredholm determinant, Convergence of Fredholm series.

## Unit III

Solution of integral equations by method of Laplace transform, Convolution type kernel, Solution of integral equation by Fourier transform method, Singular integral equation, Cauchy and Hilbert type kernel, Solution of singular integral equation having kernel of  $h(s)-h(t)$  type.

## Unit IV

Boundary value problem, Initial value problem, Green's function. Construction of Green's function from given boundary value problem, Applications of Green's function, Modified Green's function, Dirac Delta function.

### Recommended books:

1. Linear integral equations theory & techniques, R.P. Kanwal Academic Press New York 1971.
2. Linear integral equation & boundary value problem by M. D. Rai Singhania, S. Chand & Co. 2005.
3. Integral Equation by Shanti Swaroop, Krishna Prakashan, 1989.
4. A first course in integral equation, A M Wazwar, Saint Xavier Univ. USA Dec 1997.

## Paper 3(i)

### Advanced Fluid Mechanics

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Advanced Fluid Mechanics**

**Course Type: Elective paper**

**Course Level: PG**

## Unit I

Three dimensional irrotational flow, Axisymmetric flow, Stokes Stream function, Axisymmetric potential flow, Liquid streaming past a stationary sphere, Uniform motion of a sphere in a liquid at rest at infinity, Concentric sphere (problem of initial motion).

## **Unit II**

Vortex motion, Vortex filament, Complex potential, Image of vortex, Complex potential due to vortex doublet, Spiral vortex, Rankine combined vortex, Rectilinear vortex with elliptic cross-section, Routh's theorem, Motion of any vortex, Kirchhoff vortex theorem.

## **Unit III**

Newton's Law of viscosity, Newtonian and non-Newtonian fluids, Definition of stress, strain and their relations, Relation between stresses and rate of strain, Navier-Stokes equation, Dissipation of energy, Diffusion of vorticity, Laminar flow of Viscous incompressible fluids.

## **Unit IV**

Fluid pressure: Equation of pressure, Condition of equilibrium, Lines of force, Homogeneous and heterogeneous fluids, Elastic fluids, Surface of equal pressure and density, Rotating fluids.

Fluid pressure on plane surface: Centre of pressure, Resultant pressure on curved surfaces.

### **Recommended books:**

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydrodynamics, CBS publishers and Distributors, Delhi, 1988.
2. R.K. Rathy, An introduction to fluid Dynamics, Oxford and IBH Publishing Company, New Delhi; 1976.
3. F. Charlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S.W. Yuan, Foundations of Fluid Dynamics, Prentice – Hall of India, 1988.
5. B. D. Sharma, Hydro-statics, Kedar Nath Ram Nath Publication.

## **Paper 3(ii)**

### **Wavelet Analysis**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Wavelet Analysis**

**Course Type: Elective paper**

**Course Level: PG**

## Unit I

Fourier transforms, Inverse Fourier transforms, Basic properties of Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of square integrable functions, Poisson's summation formula.

## Unit II

Construction of wavelets on  $Z_N$ , Haar wavelets on  $Z$ , Shannon wavelet, The Gabor

transform, Heisenberg uncertainty principle, Description of  $l^2(Z)$ ,  $L^2[-\pi, \pi]$  and  $L^2(R)$ , Parseval's relation.

## Unit III

Multi resolution analysis, MRA wavelets, Scaling functions with finite two scale relations, Direct sum decomposition of  $L^2(R)$ , Linear phase filtering, Low-pass filters and scaling

functions, Compactly supported wavelets, Wavelets and their duals.

## Unit IV

Franklin wavelets on  $\mathbf{R}$ , Orthogonal wavelets and wavelet packets, Example of orthogonal wavelets, Identification of wavelet packets, Construction of compactly supported orthogonal wavelets, Orthogonal wavelet packets, Orthogonal decomposition of wavelet series.

### Recommended books:

1. C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.
2. I. Daubechies, Ten Lectures on Wavelets, CB5-NSF Regional Conference in Applied Mathematics, 61, SIAM, 1992.
3. M. W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer-Verlag, 1999.
4. E. Hernandez and G. Weiss, A First Course on Wavelets, CRC Press, 1996.

## Paper 3(iii)

### Special Theory of Relativity

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Special Theory of Relativity**

**Course Type: Elective paper**

**Course Level: PG**

**Unit 1**

## **Unit I**

Historical background and postulates of special relativity, Relativity of simultaneity, Lorentz transformation and its consequences, Relativistic addition of velocities.

## **Unit II**

Doppler effect, Space-time diagrams, Time order and Space-time separation of events, Null cone, The twin-paradox.

## **Unit III**

Relativistic mass and momentum, The equivalence of mass and energy, The relativistic force law and dynamics of a single particle, Energy momentum tensor of incoherent matter.

## **Unit IV**

Principle of equivalence, Principle of general covariance, Criteria for gravitational field equations, Einstein field equations, Gravity as a geometric Phenomenon. The energy momentum tensor, Inclusion of forces in the field equations and their classical limits.

### **Recommended books:**

1. Rindler W. Special Relativity, 1966.
2. Resnick, R., Introduction to special relativity, Wiley-Eastern, 1990.
3. Special Theory of Relativity, Anshan Publishers-2009.

## **Paper 3(iv)**

### **Differential Geometry of Manifolds**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Differential Geometry of Manifolds**

**Course Type: Elective paper**

**Course Level: PG**

## **Unit I**

Analysis of curve, Curvatures related to curves, Curvature tensor, Torsion tensor and skew curvature tensor, Examples based on curvature tensor, Torsion tensor and skew curvature tensor, Relation between curvature tensor and their derivatives, Study of surface, Analytical study of first and second fundamental form of surfaces.

## **Unit II**

Tensor space, Dimension and basis of tensor space, Rank of tensor, Quotient law of tensor, Uses of Christoffel symbols in real world, Analysis and uses of gradient, divergence and curl.

### **Unit III**

$C^r$ -curve, Chart, Atlas, Definition of topological manifold, Differentiable manifold, Examples of manifold, One dimensional manifold, Examples of two-dimensional manifold, three dimensional and n-dimensional manifolds, Tangent space, Tangent bundle, Lie groups, Lie derivative.

### **Unit IV**

Complex manifolds, Examples of complex contact manifolds, Contact manifold, Examples of contact manifolds, Difference of complex and contact manifold.

#### **Recommended books:**

1. Elementary Topics in Differential Geometry, Thorpe J.A, Springer 1994.
2. Tensor calculus, De UC, Shaikh AA, Sengupta Joydeep, 2005
3. An introduction to differentiable manifold, Willmore T.J
4. A Course of Tensors with Applications, Mishra R.S, Pothishala Pvt Ltd,1965.
5. Differential Geometry of Manifolds, De.U.C Narosa Publishing House 2005
6. Complex and Contact Manifold, De U.C Narosa Publishing House,2008.

## **Paper 3(v)**

### **Advanced Discrete Mathematics**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Advanced Discrete Mathematics**

**Course Type: Elective paper**

**Course Level: PG**

#### **Unit I**

Semigroups and Monoids: Definitions and examples of semigroups and monoids (including those pertaining to concatenation operation), Homomorphism of semigroups and monoids, Congruence relation and quotient semigroup, Subsemigroup and submonoids, Direct products, Basic homomorphism theorem.

#### **Unit II**

Lattices: Lattices as partially ordered sets and their properties, Lattices as algebraic systems, Sub-lattices, Direct products and homomorphisms, Some special lattices such as complete, complemented and distributive lattices.

### **Unit III**

Boolean Algebra: Boolean algebras as lattices, Various Boolean identities, The switching algebra example, Sub-algebras, Direct products and homomorphisms, Join-irreducible elements, Atoms and minterms, Boolean forms and their equivalence, Minterm Boolean forms, Sum of products, Canonical forms, Minimization of the Boolean functions.

### **Unit IV**

Grammars and Languages: Phrase structure grammars, Rewriting rules, Derivations, Sentential forms, Language generated by grammar, Regular, Context free and Context sensitive grammar and languages, Regular sets, Regular expressions and the pumping lemma, Kleene's theorem, Notions of syntax analysis, Polish notations, Conversion of infix expressions to Polish notations, The reverse Polish notations.

#### **Recommended books:**

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw-Hill Publishing Company Limited.
2. C.L. Liu, Elements of Discrete Mathematics, Tata McGraw-Hill Publishing Company Limited.
3. H.K. Pathak & J.P. Chauhan, Advanced Discrete Mathematics, Shiksha Sahitya Prakashan.

## **Paper 4(i)**

### **Operator Theory**

**Credits: 04**

**Max Marks: 100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Operator Theory**

**Course Type: Elective paper**

**Course Level: PG**

#### **Unit I**

Introduction to real Banach and real Hilbert spaces, Adjoint of an operator on a Hilbert space, Self-adjoint operators, Normal operators and Unitary operators on Hilbert spaces, Projections on a Hilbert space.

#### **Unit II**

Compact operators, Spectral theory of linear operators in normed linear space, Spectral theory of linear operators in finite dimensional normed linear spaces, Spectral properties of bounded linear operators.

### **Unit III**

Determinant and the spectrum of an operator, Spectral theorem, Resolvent and its properties, Spectrum and its properties, Residual spectrum, Approximate spectrum, Analyticity of the resolvent operator, Use of complex analysis in spectral theory, Spectral radius and the spectral mapping theorem for polynomials.

### **Unit IV**

Banach algebras, Banach algebras with identity, Division algebra, Further properties of Banach algebra, Compactness of the spectrum, Ideals and maximal ideals of a complex commutative Banach algebra, radicals, Gelfand-Naimark theorem.

### **Recommended books:**

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons.
3. G. Bachman and L. Narici, Functional Analysis, Academic Press, New York, 1966.
4. J. B. Conway, A Course in Operator Theory, Springer.
5. N. Saran and S. L. Shukla, Functional Analysis, Pragati Prakashan, Meerut.
6. J. N. Sharma and A. R. Vasishtha, Functional Analysis, Krishna Prakashan Media (P) Ltd., 2015.

## **Paper 4(ii)**

### **Calculus of Variations**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Calculus of Variations**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Evolution of calculus of variations and contribution of Bernoulli.

Functional, Euler's equation of extrema for functionals involving first order derivative, Functional dependent on more than one dependent variables, Functional dependent on two independent variables: Euler Ostrogradsky equation, Generalised Euler's Ostrogradsky Equation. Functional dependent on higher order derivative: Euler Poisson's equation.

### **Unit 37**

Weierstrass function, Sufficient condition of Extrema: Legendre condition, Isoperimetric problem, Local maxima, Invariance of Euler's equation under coordinate transformation, Problems based on Legendre condition.

### **Unit III**

Moving boundary value problem, Condition of extrema: Transversality condition, Variational problem with movable boundary for a functional dependent on two functions, One sided variation, Reflection & refraction of extremals, Diffraction of light rays.

### **Unit IV**

Field extremal, Jacobi condition, Second variation, Canonical equations, Applications of calculus of variations in Lagrange's equation, Application of calculus of variations in the Hamilton's equation, Hamiltons variational principle.

### **Recommended books:**

1. Calculus of Variations with Applications, AS Gupta, Printice Hall of India, 1997.
2. Calculus of Variations, I.M. Gelfand and S.V. Fomin, Dover Publication, 2000.
3. Calculus of Variations, Mukesh Singh, Krishna Publications, 2015.

## **Paper 4(iii)**

### **Mathematical Modelling**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Mathematical Modelling**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Introduction to mathematical modelling: need, classification, modelling process, Elementary mathematical models; Role of mathematics in problem solving. Single species population model: The exponential model and the logistic model, Harvesting model and its critical value.

### **Unit II**

Modelling with ordinary differential equations: Overview of basic concepts in ODE and stability of solutions: steady state and their local and global stability, Linear and non-linear growth and decay models. Compartment models. Mathematical modelling of geometrical problems, reaction kinetics. Some applications in economics, ecology, Modelling in epidemiology (SIS, SIR, SIRS models) and basic reproduction number.

### **Unit 38**

Mathematical models through difference equations, Some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modelling through difference equations in economics and finance, Mathematical modelling through difference equations in population dynamics.

### **Unit IV**

Mathematical modelling through partial differential equations, Situations giving rise to of partial differential equation models. The one-dimensional heat equation: derivation and solution. Wave equation: derivation and solution.

#### **Recommended books:**

1. J.N. Kapur, Mathematical Modelling, New Age Intern. Pub.
2. J.N. Kapur, Mathematical Models in Biology and Medicine, East-West Press.
3. Fred Brauer and Carlos Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer.
4. Frank R. Giordano, William Price Fox, Maurice D. Weir, A First Course in Mathematical Modelling, 4th Ed., Charlie Van Wagner.
5. Walter J. Meyer, Concept of Mathematical Modelling, McGraw-Hill.
5. Zafar Ahsan: Differential Equations and Their Applications, PHI learning Private Limited, New Delhi.
6. Steven H. Strogatz, Nonlinear dynamics and chaos, With Applications to Physics, Biology, Chemistry, and Engineering.

## **Paper 4(iv)**

### **Cosmology**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Cosmology**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Mach's principle, Einstein modified field equations with cosmological term, Static cosmological model of Einstein and De-Sitter, Their derivation, Properties and comparison with the actual universe.

### **Unit 39**

Hubble's law, Cosmological principles, Weyl's postulate. Derivation of Robertson-Walker metric, Hubble and deceleration parameters, Redshifts, Redshift versus distance relation, Angular size versus redshift relation and source counts in Robertson-Walker space-time.

### **Unit III**

Friedmann models, Fundamental equation of dynamical cosmology, Critical density, Closed and open Universe, Age of the Universe, Matter dominated era of the Universe, Einstein- De-Sitter model, Particle and event horizons.

### **Unit IV**

Eddington-Lemaitre models with I- term, Perfect Cosmological principle, Steady state Cosmology.

### **Recommended books:**

1. R. C. Tolman, Relativity, Thermodynamics and Cosmology, Clarendon Press, Oxford, 1934.
2. S. Weinberg, Gravitation and Cosmology, John Wiley, 1972.
3. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, 1998.
4. J. N. Islam, An Introduction to Mathematical Cosmology, Cambridge University Press, 1999.
5. J. A. Peacock, Cosmological Physics, Cambridge University Press, 1999.

## **Paper 4(v)**

### **Cryptography**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Cryptography**

**Course Type: Elective paper**

**Course Level: PG**

### **Unit I**

Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques- Substitution and transposition ciphers, Caesar cipher, Play fair cipher, Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

### **Unit II**

Polynomial and modular arithmetic, Introduction to finite field of the form  $GF(p)$  and  $GF(2^n)$ , Fermat theorem and Euler's theorem (statement only), Chinese remainder theorem, Discrete logarithm.

## **Unit 40**

Advanced Encryption Standard (AES), Stream ciphers, Introduction to public key cryptography, One-way functions, The discrete logarithm problem, Diffie-Hellman key exchange algorithm, RSA algorithm and security of RSA, The ElGamal public key cryptosystem, Introduction to elliptic curve cryptography.

## **Unit IV**

Information/Computer Security: Basic security objectives, security attacks, security services, Network security model, Cryptographic hash functions, Secure hash algorithm, SHA-3. Digital signature, ElGamal signature, Digital signature standards, Digital signature algorithm.

### **Recommended books:**

1. William Stallings, Cryptography and Network Security, Principles and Practice, 5<sup>th</sup> ed., Pearson Education, 2012.
2. Douglas R. Stinson, Cryptography: Theory and Practice, CRC Press, 3<sup>rd</sup> ed., 2005.
3. J.A. Buchmann, Introduction to Cryptography, 2<sup>nd</sup> ed., Springer 2003.
4. W. Trappe and L.C. Washington, Introduction to Cryptography with Coding Theory, Pearson, 2006.
5. J. Hoffstein, J. Pipher, and J. H. Silverman, An Introduction to Mathematical Cryptography, 2<sup>nd</sup> ed., Springer, 2014.

## **Computational Mathematics with Python-II**

**Credits: 04**

**Max Marks:100**

**Evaluation:** Continuous Internal Assessment – 25 marks

Semester End Examination – 75 Marks

**Course Title: Computational Mathematics with Python-II**

**Course Type: Practical**

**Course Level: PG**

Introduction and application of SymPy for symbolic computing, Matplotlib Package  
Application of NumPy for plotting and visualisation, Application of SciPy for Vectors,  
Matrices, multidimensional array and numerical analysis.

### **Suggested List of programmes:**

1. Plotting one or multiple Curve (Cartesian, Polar and Parametric).
2. Plotting Curve from Data.
3. Plotting Points.

4. Plotting bar Chart.
5. Plotting Pie Chart.
6. Plotting Histogram.
7. Linear Regression.
8. Matrices and Vectors Operations.
9. Solution of simultaneous equation by
  - I. Matrix Inversion
  - II. Cramer's Rule
  - III. Gauss Elimination
  - IV. Gauss Jordan
  - V. Jacobi Iterative
  - VI. Gauss Seidel
10. Solution of Ordinary and Partial differential equation and plotting the solution as curve or surface.
11. Find the root of algebraic/transcendental equation by using
  - I. Fixed point iterative method
  - II. Bisection's Method
  - III. Newton Raphson's Method
  - IV. Secant Method
  - V. Muller's Method
  - VI. Regula Falsi Method

**Recommended books:**

1. Numerical Python, Robert Johansson, Apress publication.
2. Practical Numerical computing using Python, Mahendra Verma.
3. Matplotlib Plotting Cookbook, Alexandra Devert, Packt publishing.
4. Python Programming and Numerical Methods guides for Engineers and Scientist, Qiningkai Kong, Timmy Siau and Alexandre M. Bayen, Academic Press.
5. Numerical Method in Engineering with Python, Jaan Kiusalaas, Cambridge University Press.<sup>3</sup>