SIR PADAMPAT SINGHANIA UNIVERSITY

Udaipur

SCHOOL OF ENGINEERING

Course Curriculum of Ph.D. Degree Programme in MATHEMATICS (Batch-2018-19)

Credit Structure

Category	Credits
Departmental Major Subjects	6
Minor Subject	3
Total	9

Note: The student has to select the courses of minimum 6 credits from the departmental major subjects and a compulsory Research Methodology course (common to all PhD Scholars) of 3 credits.

Course Structure: Ph.D. Degree (2018-19)

(Departmental Major Subject)

S.No.	Course Code	Course Title	L	T	P	Credit(s)
1	MA-601	Special Functions	3	0	0	3
2	MA-602	q-Hypergeometric Functions	3	0	0	3
3	MA-603	Multiple Gaussian Hypergeometric Series	3	0	0	3
4	MA-604	Generating Functions	3	0	0	3
5	MA-605	Theory of Relativity	3	0	0	3
6	MA-606	Relativity & Cosmology	3	0	0	3

Minor Subject

S.No.	Course Code	Course Title	L	T	P	Credit(s)
1	BM-617	Research Methodology	3	0	0	3

Detailed Syllabus for Ph.D. Degree Programme in Mathematics

Semester - I

(Departmental Major Subject)

MA-601 L–T–P–C
Special Functions 3–0–0–3

Objective: "*Special functions" arose as solutions of differential equations or integrals of transcendental functions & have found several applications in different areas of science & engineering. This course provides background for research in this field.*

Course Content

Gamma & Beta functions: Weierstrass's & Euler's product definitions of $\Gamma(z)$, Euler's integral for $\Gamma(z)$ & Beta function, Factorial function, Legendre's duplication & Gauss's multiplication formulae, Gauss's Hypergeometric Function ${}_2F_1(z)$, Euler's integral representation of ${}_2F_1(z)$ & applications, Contiguous function relations, Series manipulations, Hypergeometric summations & transformations. Generalized Hypergeometric Functions; Saalschütz's, Whipple's & Dixon's theorems. Confluent Hypergeometric Functions; Kummer's first & second formula. Generating Functions, Orthogonal Polynomials: Legendre, Hermite, Laguerre, Gegenbaur, Ultraspherical & Jacobi; Recurrence relations. Sister-Celine's technique for pure recurrence relations.

Text/Reference Books

1. Special Functions. Rainville E. D. MacMillan Co.: New York. 1967.
2. Special Functions. Andrews G. E., Askey R. & Roy R. Cambridge University Press: Cambridge. 1999.
3. Generalized Hypergeometric Functions. Slater L. J. Cambridge University Press: Cambridge. 1966.
4. The Special Functions and their Approximations: Vol. I. Luke Y. L. Academic Press: London. 1969.
5. Generalized Hypergeometric Series. Bailey W. N. Cambridge University Press, Cambridge, reprinted by Hafner: New York. 1964.

Detailed Syllabus for Ph.D. Degree Programme in Mathematics

Semester - I

(Departmental Major Subject)

MA-602 L–T–P–C
q-Hypergeometric Functions 3–0–0–3

Objective: *This course provides an introduction to the field of the basic (or q-) hypergeometric series & provides background for research in this field.*

Course Content

Basic (or q-) analogue of hypergeometric functions, The q-binomial theorem, Heine's transformation formulas for 2¢1 series, Heine's q-analogue of Gauss' summation formula, Jacobi's triple product identity, theta functions & elliptic numbers, The Bailey's transform, its q-analogue & applications, A q-analogue of Saalschütz's summation formula, The Bailey-Daum summation formula, q-analogues of the Karlsson-Minton summation formulas, The q-gamma & q-beta functions, The *q*-integral, Summation, transformation & expansion formulas, Well-poised, nearly-poised, & very-well-poised hypergeometric & basic hypergeometric series, A summation formula for a terminating very-well-poised 4¢3 series, A summation formula for a terminating very-well-poised 6¢5 series, Watson's transformation formula for a terminating very-well-poised 8¢7 series, Jackson's sum of a terminating very-well-poised balanced 8¢7 series, Some special & limiting cases of Jackson's & Watson's formulas: the Rogers-Ramanujan identities, Bailey's transformation formulas for terminating 5¢4 & 7¢6 series, Bailey's transformation formula for a terminating $_{10}¢_{9}$ series

Text/Reference Books

1. Basic Hypergeometric Series. Gasper G. & Rahman M. Cambridge University Press: Cambridge. 2004.

2. Generalized Hypergeometric Functions. Slater L. J. Cambridge University Press: Cambridge. 1966.
3. q-Hypergeometric Functions and Application. Exton H. Ellis Horwood Ltd.: Chichester. 1983.
4. Special Functions. Andrews G. E., Askey R. & Roy R. Cambridge University Press: Cambridge. 1999.
5. Generalized Hypergeometric Series. Bailey W. N. Cambridge University Press, Cambridge, reprinted by Hafner: New York. 1964.

Detailed Syllabus for Ph.D. Degree Programme
in
Mathematics

Semester - I

(Departmental Major Subject)

MA-603 L–T–P–C
Multiple Gaussian Hypergeometric Series 3–0–0–3

Objective: *This course provides an introduction to the field of multiple hypergeometric series & provides background for research in this field.*

Course Content

Introduction & definitions, Problems & historical background, Gaussian hypergeometric series, its generalizations & properties, hypergeometric series in two variables & their properties, multiple hypergeometric series of Lauricella, their generalizations & properties, the triple hypergeometric series of Srivastava & its special cases & properties, Order classification & its apparent drawbacks, Horn's theorem of convergence, Region of convergence.

Text/Reference Books

1. Multiple Gaussian Hypergeometric Series. Srivastava H. M. & Karlsson P. W. Ellis Horwood Ltd.: Chichester. 1985.
2. Multiple Hypergeometric Series and Applications, Exton H. Ellis Horwood Ltd.: Chichester. 1976.

Detailed Syllabus for Ph.D. Degree Programme
in
Mathematics

Semester - I

(Departmental Major Subject)

MA-604 L–T–P–C
Generating Functions 3–0–0–3

Objective: *This course provides an introduction to the field of the generating functions of hypergeometric series & provides background for research in this field.*

Course Content

Introduction and definitions, Series rearrangement techniques, applications to Jacobi, Gegenbauer and Laguerre polynomials; Decomposition technique and applications, Fractional Derivative technique and applications, Generating Functions via Lagrange's expansion and Gould's identities, Brown's theorem, Generalizations by Srivastava, Zeitlin and Buchman, Carlitz's theorem and its multiparameter and multivariable extensions. q-analogues of the generating functions.

Text/Reference Books

1. A Treatise on Generating Functions, Srivastava H. M. & Manocha H. L. Ellis Horwood Ltd.: Chichester. 1984.
2. Obtaining Generating Functions. McBride E. B. Springer. 2012.

Detailed Syllabus for Ph.D. Degree Programme in Mathematics

Semester - I

(Departmental Major Subject)

MA-605 L–T–P–C
Theory of Relativity 3–0–0–3

Objective: *This course provides fundamentals of general theory of relativity which are important background for researchers to study the various cosmological models.*

Course Content

Introduction to Special Relativity: Space-time approach, 4 vectors, geometric construction. Introduction to General Relativity: Gravitational red shift, Principle of Equivalence; Matter & space time curvature. Curved Space-time, Principle of Covariance, coordinate transformations; Tensor Analysis, geometry of curved space. How matter moves in curved space-times: connection & Geodesic equations. How curvature of space-time shows up: curvature & geodesic deviations. Einstein's Equation: Vacuum solutions; Relativistic matter; Dynamics of space-time & matter

Text/Reference Books

1. A First Course in General Relativity. Schutz B. F. 2nd Ed. Cambridge University Press. 2009.
2. Gravitation and Cosmology. Weinberg S. 1st Ed. John Wiley & Sons. 1972.
3. Problem Book in Relativity and Gravitation. Lightman A.P., Press W.H., Price R.H. & Teukolsky S. A. Princeton University Press. 1975.
4. Exploring Black Holes: Introduction to General Relativity. Taylor E. F. &. Wheeler J. A. 1st Ed. Addison Wesley. 2000.
5. General Relativity. Wald R. M. 1st Ed. University of Chicago Press. 1984.

Detailed Syllabus for Ph.D. Degree Programme in Mathematics

Semester - I

(Departmental Major Subject)

MA-606 L–T–P–C
Relativity & Cosmology 3–0–0–3

Objective: *This course provides fundamentals of general theory of relativity which are important background for researchers to study the various cosmological models.*

Course Content

Linearised Theory: Gravitational radiation; Einstein's equation for weak fields; Generation, propagation & detection of gravitational waves; Conservation of energy momentum & angular momentum.

Relativistic Astrophysics: Spherically symmetric space-times; Schwarzschild metric; Stellar models & gravitational collapse; Trajectories around a compact object. Black holes.

Relativistic Cosmology: Cosmological principles; Standard Model: Robertson-Walker metric & Friedmann solution; De Sitter space-time & inflationary cosmology; The early universe.

Text/Reference Books

1. Cosmology: The origin and evolution of cosmic structures. Coles P. & Lucchin F. 2nd Ed. John Wiley and Sons. 2002.
2. Gravitation and Cosmology. Weinberg S. 1st Ed. John Wiley and Sons.1972.
3. Problem Book in Relativity and Gravitation. Lightman A. P., Press W. H. Price R. H. & Teukolsky S. A. Princeton University Press. 1975.
4. Exploring Black Holes: Introduction to General Relativity. Taylor E. F. &. Wheeler J. A. 1st Ed. Addison Wesley. 2000.
5. Introduction to Cosmology. Narlikar J. V. 3rd Ed. Cambridge University Press.2002.

Detailed Syllabus for Ph.D. Degree Programme
in
All Disciplines

Semester - I

(Minor Subject)

BM-617 L–T–P–C
Research Methodology 3–0–0–3

Objective: *This course aims at helping students appreciate the importance of carrying out research in a planned and systematic manner. It discusses different research designs before providing students with an understanding of sampling for research purposes. It also provides students statistical tools to analyse and compare research data and test hypotheses for arriving at statistical valid results. Finally the course discusses ethical issues relating to sampling & research before providing inputs on development of synopsis that forms the basis of formal research*.

Course Content

Research & its Methodology: Definitions, Nature, Scope & Types of research, Stating the research problem and developing an approach, Importance of statement of research objectives.

Research Design and Research Instruments: Comparison on important research designs (Exploratory, Descriptive and Experimental); Methods of Data Collection - Observational and Survey Methods, Questionnaire Design.

Sampling Methods and Sampling Distributions: Statistics and Parameter, Sampling distributions - conceptual basis; standard error; sampling from normal populations; relationship between sample size and standard error; Finite Population Multiplier.

Measurement and Scaling: Discussion on primary scales of measurement, discussion on comparative scaling technique (paired comparison scaling, rank order scaling, constant sum scaling) and non-comparative scaling techniques (continuous rating

scale, itemized rating scale, Likert scale, Semantic differential scale, staple scale); Challenges of ensuring accuracy (reliability and validity of research).

Hypothesis Testing: Basic Concepts – Null and Alternative Hypotheses; Type I and Type II errors; the significance level. Chi–square and Analysis of Variance: Chi-square as a test of (a) independence and (b) goodness of fit; ANOVA, Non parametric tests & its applications.

Multivariate analysis using SPSS: Factor Analysis, Multiple Regression Analysis, Multiple Discriminant Analysis and Logistic Regression, Multivariate Analysis of Variance.

Presenting Research findings: Tabulation of Data, Synopsis & Report Writing, Ethical aspects of research.

Use of Analytical Tools for Research: Analysis of data through spreadsheets, Use of SPSS, Use of open source tools like R for research.

List of Exercises (Excel/SPSS/R)

1. Estimating regression & correlation coefficients;
2. Estimating probability based on Binomial, Poisson & Normal distribution;
3. Estimating standard error using central limit theorem (small & large population);
4. Hypotheses testing for all three kinds of hypotheses;
5. Use of Chi-Squared value to estimate population variance & hypotheses testing;
6. Use of F-distribution for comparing multiple samples;
7. Non parametric testing as a tool for hypotheses tests;
8. Use of other open source software packages for research purposes.

Text/Reference Books

1. Statistics for Management. Levin R.I. and Rubin D.S. 7th Ed. Dorling Kindersley Pvt Ltd. 2008.
2. Quantitative Techniques. Kothari C.R. Vikas Publishing House. 2009
3. Multivariate Data Analysis. Hair J.F.Jr., Black W.C. and Babin B.J. 7th Ed. Prentice Hall. 2009.
4. Statistical Methods. Gupta S.P. 30" Ed. Sultan Chand. 2012.
5. Statistical Methods. Das N.G.McGraw Hill Education (India) Pvt. Limited. 2008.