# Islamic University of Science & Technology

## Department of Mathematical Sciences

### Ph.D. Course Work

### Course Structure (Mathematics)

| Course Type | Course Code | Course Title | Course Type | Maximum Marks | | | Credit Distribution | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal | Final | Total | L | T | P | |
| Core | RPE900C | Research and Publication Ethics | Core | 25 | 25 | 50 | 2 | 0 | 0 | 2 |
| | MTH901C | Research Methodology | Core | 50 | 50 | 100 | 3 | 1 | 0 | 4 |
| | MTH905C | Advanced Linear Algebra | Core | 50 | 50 | 100 | 3 | 1 | 0 | 4 |
| Research Centric | STA903C | Seminar on Recent Developments in the Area of Research | Core | Write-up-50<br>Presentation-30<br>Viva-20 | | | | | | 2 |
| Discipline Centric Elective Courses | MTH 906E | Advanced Time-Frequency Analysis | Elective | 50 | 50 | 100 | 3 | 1 | 0 | 4 |
| | MTH907E | Recent Advances in Spectral Graph Theory | Elective | 50 | 50 | 100 | 3 | 1 | 0 | 4 |
| | MTH908E | Special Functions and Integral Transforms | Elective | 50 | 50 | 100 | 3 | 1 | 0 | 4 |
| **Total credits** | | | | | | | | | | **16** |

## Course Title: Advanced Linear Algebra

**Course Code:** MTH905C
**Credit :** 4
**Marks :** 100

### Unit-I

**Eigen values and Eigen vectors:** Special Matrices and their Eigen values, characteristic Polynomial, Elementary properties of Eigen systems, Diagonalizability by similar Transformation, functions of Diagonalizable matrices, normal matrices, nilpotent matrices, Jordan Structure, partitioning of matrices.

### Unit-II

**Inner Products:** Inner product spaces, orthogonal vectors, Gram-Schmidt procedure, Unitary and orthogonal Matrices, orthogonal reduction, Discrete reduction, Discrete Fourier Transform, complementary subspaces.

### Unit-III

**Decomposition and positive Definite Matrices:** Range-nullspace decomposition, orthogonal decomposition, Orthogonal projection, Perron-Frobenius Theory, Positive matrices, Minima, Maxima and saddle points, Tests for positive definiteness, singular value decomposition, stochastic matrices, Markov Chains.

### Unit IV:

**Norms:** Vector norms, Matrix norm and Trace norm of a matrix, Location and perturbation of Eigen values, Singular values and eigenvalues, Ky Fan k-norm, Laplacian Eigen values of a Laplacian Matrix, Laplacian spectral radius, Basic upper and lower bounds interms Laplacian Eigen values,

### Recommended Books:


1. Carl D. Meyer, Matrix Analysis and Applied Linear Algebra.
2. Gilbert Strang, Linear Algebra and its applications, Fourth Edition.
3. Richard A. Brualdi, DragosCvetkovic, A combinatorial Approach to Matrix Theory and Its Applications.
4. R. Horn and C. Johnson, Matrix Analysis, Cambridge University press, 1985.

5. Seymour Lipschutz and Marc Lipson, Schaum's outlines, Linear Algebra
6. R. Horn and C. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1991.
7. Vinit K. Sinha, Introduction to Matrix Theory
8. Xian- Da-Zhang, Matrix Analysis and Applications.
9. R. Horn and C. Johnson, Matrix Analysis, Cambridge University press, 1985.
10. R. Horn and C. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1991.

**Course: Advanced Time-Frequency Analysis**

**Course Code: MTH 906E**

**Credits: 4**

**Marks:100**

**Unit-I**

Fourier series, Fourier transforms, Convolution theorem, Plancherel's and Parseval's formulae, Poisson summation formula, Shannon-Whittaker sampling theorem, Heisenberg's uncertainty principle, Applications of Fourier transforms in Mathematical Statistics, Ordinary differential equations, Integral equations, and Partial differential equations.

**Unit-II**

Windowed Fourier transform, fundamental properties of windowed Fourier transform including convolution theorem, Moyal's principle, reconstruction formula and characterization of range, Generalized Fourier transform, Quaternion Fourier transform, fractional Fourier transform, linear canonical transform, Stockwell transform and its properties.

**Unit-III**

Continuous wavelet transforms in L2(R) and their fundamental properties, Examples of orthonormal wavelets and their Fourier transforms (Haar, Mexican, Meyer, Morlet), Moyal's formula, Parseval's formula, Energy preserving relation, Inversion formula, Discrete wavelet transform, Discrete Daubechies transformation.

**Unit-IV**

Motivation, definition and examples of Multiresolution Analysis (MRA) with special reference to Haar MRA and Shannon's MRA, Properties and characterizations of scaling functions, Construction of orthonormal wavelet bases in L2(R), Characterization of orthonormal wavelets via Fourier transforms, Dimension function. nonuniform MRA, Biorthogonal scaling functions and wavelets, Wavelet packets.

**Recommended Books:**


5. S. T. Ali, J. P. Antoine and J. P. Gazeau (2014): *Coherent States, Wavelets, and Their Generalizations,* Springer, New York.
6. M.W. Wong (2002): *Wavelet Transforms and Localization Operators*, Birkhauser, Boston.
7. L. Debnath and Firdous A. Shah (2015): *Wavelet Transforms and Their Applications,* Birkhauser, New York.
8. D. K. Ruch and P. J. Van Fleet (2009): *Wavelet Theory,* John Wiley.
9. P. Nickolas, *Wavelets (2017): A Students Guide*, Cambridge University Press.
10. G. Kutyniok and D. Labate, *Shearlets (2012): Multiscale Analysis for Multivariate Data*, Birkhauser-Springer, Basel.

**Research Papers:**


1. M. Hutnikova and A. Miskova (2015): Contineous Stockwell transform: Coherent states and localization operators, *J. Math. Physics*, 56, 1-14.
2. J.P. Antoine and P. Vandergheynst (2007): Wavelets on the two sphere and other conic sections, *J. Fourier Anal. Appl.*, 13, 369-386.
3. J.P. Antoine, D. Rosca and P. Vandergheynst (2010): Wavelet transform on manifolds: Old and new approach, *Appl. Comput. Harmon. Anal.*, 28, 189-202.
4. J.P. Antoine and I. Mahara (1999): Galilean wavelets: Coherent states of the affine Galilei group, *J. Math. Physics*, 40(11), 5956-5971.
5. J.P. Antoine (1995): Galilean coherent states and wavelets, *Math. Phys. Stud.* 18, 15-26.
6. M. Holschneider (1995): Wavelet analysis over abelian groups, *Appl. Comput. Harmon. Anal.*, 2, 52-60.
7. A.A. Arefijamaal and R.A. Kamyabi-Gol (2007): A characterization of square integrable representations associated with CWT, *J. Sci. I.R. Iran*, 18(2), 159-166.
8. H. Fuhr (1998): Continuous wavelet transforms with Abelian dilation groups, *J. Math. Physics*, 39(8), 3974-3986.
9. B. Torresani (1991): Wavelets associated with representations of the Weyl-Heisenberg group, *J. Math. Physics*, 32, 1273-1279.
10. D. Bernier and K. Taylor (1996): Wavelets from square integrable representations, *SIAM J. Appl. Math*, 27, 594-608.
11. H. Liu and L. Peng (1997): Admissible wavelets associated with the Heisenberg group, *Pacific J. Math.*, 1870, 101-123.
12. M.Y. Bhat and A.H. Dar (2021): wavelet packets associated with linear canonical transform on spectrum. *Int. J. Wavelets, Multiresolution and Info. Processing.*
13. M.Y. Bhat (2019): *Dual wavelets associated with NUMRA, Tamkang J. Maths 50, 119-132.*
14. F.A. Shah and M.Y. Bhat (2015): Vector valued nonuniform multiresolution analysis on local fields. *Int. J., Multiresolution and Info. Processing.*
15. A. H. Dar and M. Younus Bhat (2023): Convolution based Quadratic-Phase Stockwell Trans- form: theory and uncertainty relations, Multimedia Tools and Applications, https://doi.org/10.1007/s11042-023-16331-8.
16. M. Younus Bhat, A. H. Dar, M. Zayed and A. A. Bhat (2023): Convolution, Correlation and Un- certainty Principle in the One-Dimensional Quaternion Quadratic-Phase Fourier Trans- form Domain, mathematics, 11, 3002, https://doi.org/10.3390/ math11133002.
17. M.Younus Bhat and A.H.Dar (2023): Towards Quaternion Quadratic-phaseFourierTransform, Mathematical Methods in the Applied Sciences, https://doi.org/ 10.1002/mma.9126.
18. E.J. Candès and D.L. Donoho, Ridgelets (1999): a key to higher-dimensional intermittency? Philos. Trans. R. Soc. Lond. A 357, 2495–2509.
19. E.J. Candès and D.L. Donoho (2005): Continuous curvelet transform: I. Resolution of the wavefront set, *Appl. Comput. Harmon. Anal.* 19, 162–197.
20. D. Kumar and S. Singh (2016): Cone-adapted continuous shearlet transform and reconstruction formula, *J. Nonlinear Sci. Appl.* 9, 262-269.

**Course Title: Recent advances in Spectral Graph Theory**

**Course Code:** MTH907E
**Credit:** 4
**Marks:** 100

**Unit I:**
Types of Graphs, Isomorphism, Subgraphs, Walk, Path and Cycle, Operation on graphs, Degree Sequence and Degree set of a graph, Eulerian and Hamiltonian Graphs, Eulers Theorem, Konigsberg Bridge Problem, Trees, Different Characterizations, connectivity parameters, Whitney Theorem, Planarity, Eulers Theorem on number of regions.

**Unit II:**

Adjacency matrix, Laplacian matrix, skew Laplacian matrix, characteristic equation of a matrix associated with a graph, Eigen values of adjacency matrix, energy of a graph, Co-spectral graphs, Spectral radius of a graph, pigeonhole principle.

**Unit III:**
Eigen values of Graphs, Characteristic Polynomial, Sachs Theorem, Pairing theorem, walks and diameter, Co-spectral graphs, Eigen values of regular graphs complement of regular graphs and line graphs of regular graphs. Stable matrices and inertia, Singular value inequalities, matrix equations and the Kronecker product, Schur product theorem and its generizations.

**Unit IV:**
Variation characterizations of Eigen values of Hermitian matrix, Spectral radius of a graph, Basic upper and lower bounds, other matrices related to graphs, Energy of Graphs, Basic upper and lower bounds, Coulson integral formula, Conjectures on Eigen values and energy of a graph.

**Recommended Books:**


1. R. B. Bapat, Graphs and Matrices, Springer.
2. G. Chartrand, Graphs and Digraphs, CRC Press.
3. D. Cvetkovic, M. Doob, H. Sachs, Spectra of Graphs, Theory and Applications, Academic Press.
4. C. Godsil, Gordon Royle, Algebraic Graph Theory, Springer.
5. Richard A. Brualdi, DragosCvetkovic, A combinatorial Approach to Matrix Theory and Its Applications.
6. X. Li, Y. Shi, I. Gutman, Graph Energy, Springer.
7. S. Pirzada, An Introduction to Graph theory, Universities Press, OrientBlackSwan, 2012.
8. D. B. West, Introduction to Graph Theory, Prentice Hall.
9. Lowell W. Beineke, Robin J. Wilson, Topics in Algebraic Graph Theory
10. Jason J. Molitierno, Applications of Combinatorial Matrix Theory to Laplacian Matrices of Graphs.

## Course: Special Functions and Integral Transforms

**Course Code: MTH908E**

**Credits: 4**

**Marks:100**

### Unit-I

Hypergeometric functions, Definition of the basic hypergeometric series and function, properties of hypergeometric functions, integral formula for hypergeometric series, Heine's transformation formula, Summation, transformation and expansion formulas. Basic contour integrals. Applications to orthogonal polynomials.

### Unit-II

Jacobi triple product identity, theta functions, and elliptic numbers, elliptic and theta hypergeometric series, additive notions and modular series, Fourier transforms and its properties, Hankel and Millen transform and their properties.

### Unit-III

Legendre's differential equation and its series solution, generating functions of Legendre's polynomials $P_n(x)$, orthogonality, Laplace's first and second integral for $P_n(x)$, Rodrigues formula, Recurrence relations. Bessel's equation and its solution, Bessel function of ist kind, generating function for $J_n(x)$, Recurrence relation, integral representations for $J_n(x)$, addition formula for Bessel functions, Orthogonality.

### Unit-IV

q-shifted factorial, identities involving q-shifted factorial, q-gamma and q-binomial functions and their coefficients, q-integral.

**Recommended Books:**


1. E. D. Rainville (1960): *Special Functions*, Macmillan and Co., New York.
2. V. Kac and P. Cheung (2002): *Quantum Calculus*, Springer, New York.
3. W. N. Bailey (1964): *Generalized Hypergeometric Series,* University Press.
4. G. Gasper and M. Rahman (2004): B*asic Hypergeometric Series*, Cambridge University Press.
5. B. C. Berndt (1985): *Ramanujan's Notebooks*, Part I, Springer, New York.
6. B. C. Berndt (1989): *Ramanujan's Notebooks*, Part II, Springer, New York.


**Research Papers:**


1. L. J. Slater (1955): Some basic hypergeometric transforms, *J. London Math. Soc.* 30, 404-413
2. H. Exton (1977): The basic double hypergeometric transforms, *Indian J. Math.* 19,

35-40.

3. G. Gaper (1981): Summation formulas for basic hypergeometric series, *SIAM J. Math. Anal.*, 12, 196-200
4. M. E. H. Ismail (1981): The basic Bessel functions and polynomials, *SIAM J. Math. Anal.*, 12, 454-468
5. J. Hofbauer (1984): A $q$-analogue of the Lagrange expansion, *Arch. Math.* 42, 536-544
6. R. W. Gosper and S. K. Suslov (2000): Numerical investigation of basic Fourier series, *Contemp. Math.* 254, 199-227.
7. H. T. Koelink and J. V. Stokman (2003): The big $q$-Jacobi function transform, *Constr. Approx.* 19, 191-235
8. T. H. Koornwinder and R. F. Swarttouw (1992): On $q$-analogues of the Fourier and Hankel transforms, *Trans. Amer. Math. Soc.* 333, 445-461
9. A. A. Bhat, J. A. Ganie, M. Y. Bhat and F. A. Suleimann (2023): Generating Operators of I-transform of the Mellin Convolution Type, *J. Appl. Math. Inform.* Accepted
10. A. A. Bhat, M. Y. Bhat, H. Maqbool and D. K. Jain (2023): Generating functions of (p, q)- Analogue of Aleph-function satisfying Truesdell's ascending and descending $F_{(p,q)}$-equation, *J. Appl. Math. Inform.*41, 373-386

## Common Course for all disciplines

## Course Title : Research and Publication Ethics

**Course Code :** RPE900C
**Credits :** 2
**Marks :** 100

### UNIT 1:

**Part A: Philosophy and Ethics**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions.

**Part B: Scientific Conduct**

1. Ethics with respect to science and research
2. Intellectual honest and research integrity
3. Scientific misconducts: falsification, fabrication, and plagiarism.
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data.

### UNIT 2: Publication Ethics

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice verse, types
5. Violation of publication ethics, authorship and contributor ship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

### UNIT 3:

**Part A: Open Access Publishing**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright and self-archivingpolicies.
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, SpringerJournal Suggested, etc.

**Part B: Publication Misconduct**

Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Use of plagiarism software like Turnitin, Urkund and other opensource software tools.

**Unit 4:**

**Part A: Databases**

Indexing databases, Citation databases: Web of Science, Scopus, etc.

**Part B. Research Metrics**

Impact Factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score.Metrics: h-index, g index, i10 index, altmetrics

**Books Recommended:**


1. Indian National Science Academy (INSA) Ethics in Science and Education, research and government (2019) ISBN: 978-81939482-1-7 http://www.insaindia.res.in/pdf/Ethics_Books.pdf
2. P.Chaddah, (2018) Ethics in competitive Research , Do not get scooped; do not get plagiarized, ISBN: 978-9387480865
3. Beall, J (2012). Predatory publishers are corrupting open access, Nature ,(489 (7415), 179-179, http://doi.org/10.1038/489179a
4. Resnik, D.B(2011) What is ethics in research and why it is important , National Institute of Environmental Health Sciences , 1-10, retrieved from, http://niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine(2009) on being a scientist : guide to Responsible conduct in research : Third Edition, National Academies Press
6. Bird,A. (2006) Philosophy of Science. Routledge
7. MacIntyre, Alasdair (1967) A short story of Ethics, London

## CORE (C) COURSES

### Course Title: Research Methodology

**Course Code: STA901C**
**Credits: 4**
**Marks: 100**

**Unit I**

Concept of research in statistics- selection of topic for research, review of literature and its use in designing a research topic. Methods of data collection and preparation Mode of literature survey-books and monographs, journals, conference proceedings, abstracting and indexing journals, e-journals/books. thesis writing – computer application in scientific research, web searching; scientific articles-statistical data base.

**Unit II**

Basic concepts concerning testing of hypotheses, important parametric and non parametric tests. Hypothesis testing of means, differences between means, comparing two related samples, proportions, difference between proportions, comparing a variance to some hypothesized population variance, variances of two normal populations, correlation coefficients. Limitations of tests of hypotheses. Measurement in research, measurement scales.

**Unit III**

Scientific word processing with LaTeX and MS-word: article, thesis report and presentation-power point features, slide preparation. Statistical programming with R: simple manipulations using numbers, vectors, objects & their attributes. Arrays, matrices, lists and data frames. Grouping loops and conditions. User defined functions, probability distributions and statistical models in R.

**Unit IV**

Simulation: Concepts and Advantages of Simulation-Event Type Simulation-Random Variable Generation-U(0,1), Exponential, Gamma and Normal Random Variables–Monte Carlo simulation. The MCMC Principle, Algorithms and its Variants. Computer Oriented Numerical Methods-Algorithms for Solving Algebraic Equations-Numerical Integration-Matrix operations.

**Suggested Readings:**

1. Anderson, J., Durston, B.H., Pooole, M. (1970). Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.

2. Beveridege, B. (1979). The Art of Scientific Investigation, W.E. Norton & Co., New York.

3. Braun, J., Duncan, W. and Murdock, J. (2008). A First Course in Statistical Programming with R, Cambridge University Press, London.

4. Chambers, J. (2008). Software for Data Analysis. Programming with R, Springer, New York.

5. Crewley, M.J. (2007). The R-.Book, John Wiley, New York.

6. Dalgaard, P. (2008). Introductory Statistics with R, Springer Science, New York.

7. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K. R. (1992). Glilmpses of India's Statistical Heritage, Wiley Eastern Limited, New Delhi.

8. Hald, A. (1998). A History of Mathematical Statistics from 1750 to 1930, John Wiley & Sons, New York.

9. Kantiswarup, S., Gupta P.K. and Man Mohan (2008). Operations Research, Sultan Chand & Sons, New Delhi.

10. Kothari, C.R. and Garg, G. (2014). Research Methodology: Methods and Techniques, 3rd Edn., New Age International Publishers.

11. Lamport, L. (1999). LATEX: A Document Preparation System, Addison, Wesley, 2nd edition, New York.

12. Pannerselvan, R. (2006). Research Methodology, Prentice-Hall of India Pvt., New Delhi.

13. Robert, C.P. and Casella, G. (2004). Monte Carlo Statistical Methods, Springer Science, New York.

14. Venkataraman, M.K. (1998). Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.

## Course Title: Statistical Inference

**Course Code: STA902C**
**Credits: 4**
**C Marks: 100**

**Unit I**

Introduction and criteria of a good estimator, methods of estimation- point and interval estimation. Testing of hypotheses, null and alternative, simple and composite. Type I and Type II errors, Test function, size and power function. Concept of p-value. Review of standard one and two-sample significance tests. Most powerful tests, Neyman-Pearson lemma, Monotone Likelihood ratio property, Uniformly most powerful test.

**Unit II**

Likelihood Ratio (LR) Test. Construction of LR tests for normal mean and variance, one and two sample problems. Asymptotic distribution of LR test statistic. Sequential Analysis: Definition of Sequential Probability Ratio Test (SPRT). Fundamental relations among $\alpha$, $\beta$, A and B. Determination of A and B in practice. Wald's fundamental identity and the derivation of O.C and ASN functions. Proof of the ultimate termination of SPRT for simple hypothesis

**Unit III**

Overview classical and Bayesian paradigms; Bayes theorem and its applications. Advantage of Bayesian inference, Prior distribution, Posterior distribution, Subjective probability and its uses for determination of prior distribution. Importance of non–informative priors, improper priors, invariant priors. Conjugate priors, construction of conjugate families using sufficient statistics, hierarchical priors, Parametric Empirical Bayes.

**Unit IV**

Bayes estimation: Concept of Loss functions, type of loss functions: Types: 0-1; Absolute error; Squared error loss functions; Asymmetric loss functions such as LINEX and General Entropy loss functions; Mixture of loss functions, risk function. Bayes credible intervals, highest posterior density intervals, Bayes testing, prior and posterior odds ratio, Bayes factor. Comparison with classical procedures. Simulation studies.

**Books Recommended:**


1. Lehman, E.L. (1986): Theory of Point Estimation (Student Edition)
2. Lehman, E.L. (1986): Testing Statistical Hypothesis (Student Edition)
3. Rao, C.R. (1973): Linear Statistical Inference
4. Zacks, S (1971). Theory of Statistical Inference, John Wiley and Sons, New York.
5. Robert, C.P. (1994): The Bayesian Choice: A Decision -Theoretic Motivation (Springer Verlag New York)
6. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis (Springer)
7. Upadyaya, S.K:, Singh, U. and Dey, D.K. eds. (2007). Bayesian Statistics and its applications. Anamaya Publisher, New Delhi.
8. Koch, K. R. (2010). Introduction to Bayesian Statistics, 2nd ed. Springer.

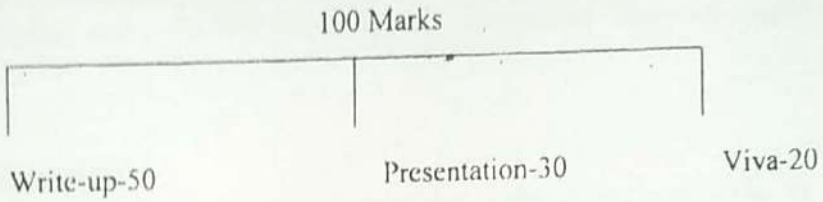
Bansal, A.K. (2007): Bayesian parametric inference, Narosa Publishing

**Course Title: Seminar on Recent Developments in the Area of Research**

**Course Code:** STA903C
**Credits: 2**
**Marks: 100**

**Review of Recent literature**:

Preparation of a comprehensive and critical review of the already published literature (recent 10 papers) in the proposed field of his/her study. The candidate will be evaluated on the basis of this review report and a seminar to be delivered at the end of the semester.



## Discipline Centric Elective (E) Courses

## Course Title: Advanced Distribution Theory

**Course Code: STA904E**
**Credits: 4**
**Marks: 100**

**Unit I**

**Lagrangian Probability Distributions**

Lagrangian expansion, some interesting properties of Lagrangian probability distribution (LPD), Use of Lagrangian expansion for generating probability distributions. Family of Lagrangian probability distributions (LPD), generalized Poisson distribution (GPD), generalized negative binomial distribution (GNBD), generalized geometric series distribution (GGSD) and generalized logarithmic series distribution (GLSD).

**Unit II**

**Modified Power Series Distributions**

Modified power series distributions (MPSD) – Some of its structural properties and applications, its relationship to Lagrangian probability distributions (LPD), generalized Poisson distribution (GPD), generalized negative binomial distribution (GNBD), generalized logarithmic series distribution (GLSD), generalized geometric series distribution (GGSD), Truncation of MPSD, Size-biased MPSD and its applications. Maximum Likelihood estimation and moment method of estimation of MPSD and its particular classes. Confidence interval of MPSD and its particular classes, Goodness of fit of MPSD. Bayesian estimation of MPSD.

**Unit III**

**Inflated and Misclassified Modified Power Series Distributions**

Introduction, inflated modified power series distributions (IMPSD), Structural properties of inflated modified power series distributions, Recurrence relations of inflated modified power series distributions, maximum likelihood estimation and Bayesian estimation of inflated modified power series distributions. Applications of inflated modified power series distributions.
Misclassified modified power series distributions, structural properties, estimation and their applications

**Unit IV**

**Generalized Continuous Distributions**

Genesis, definition and interpretation of generalized exponential distribution, generalized gamma distribution, generalized Weibull distribution: Structural properties- survival function and hazard function and reverse hazard rate function, moments, coefficient of variation, index of dispersion. Generating functions-probability generating functions, moment generating function, Methods of Estimation- method of moments (MM), maximum likelihood estimation (MLE).

**References:**


1. Consul, P.C & Famoye, F. (2006): Lagrangian Probability Distributions, ISBN: 978-0-8176-4365-2, Springer.
2. Norman L. Johnson, Adrienne W. Kemp, Samuel Kotz (2008): Univariate Discrete Distributions, 3rd Edition, John Wiley & Sons.

3. Samuel Kotz, N. Balakrishnan and Normal L. Johnson (1994): Continuous Univariate Distributions, Volume 1, 2nd Edition. John Wiley & Sons.
4. Samuel Kotz, N. Balakrishnan and Normal L. Johnson (1995): Continuous Univariate Distributions, Volume 2, 3rd Edition, John Wiley & Sons.
5. Rohatgi V.K & A.K. MD. Ehsanes Saleh (2001): An Introduction to Probability Theory and Mathematical Statistics, 2nd. John Wiley and Sons.
6. Hogg, R.V. and Craig, A.T. (1978): Introduction to Mathematical Statistics, 5/e, Pearsons Education.
7. Consul, P.C. and Shenton, L. R. (1972): Use of Lagrangian expansion for generating generalized probability distributions, SIAM, Journal of Applied Mathematics, 23, 2, 239-248.
8. Consul, P .C. and F. Famoye (1995): On the generalized negative binomial distribution. Communication in Statistics, Theory and Methods, 24(2), 459-472.
9. Gupta, P.L., Gupta, R.C. and Tripathi, R.C. (1995): Inflated modified power series distributions with applications, Communication in Statistics. -Theory and Methods.,24 (9), 2355-2374.
10. Consul, P.C. (1981): Relation of modified power series distributions to Lagrangian probability distributions, Communication in Statistics, Theory and Methods, Ser. A, 10, 2039-2046
11. Gupta, R.C. (1975a). Maximum likelihood estimation o f a modified power series distribution and some o f its applications, Communication in Statistics, Theory and Methods 4(7), 689-697.
12. Ahmad, P. B. (2020): Bayesian Analysis of Misclassified Generalized Power Series Distributions Under Different Loss Functions, Journal of Statistical Theory and Applications, 19(2), 173-184.
13. Ahmad, P. B. (2016): On the Bayes Estimators of the Parameters of Size-Biased Generalized Power Series Distributions, Communications in Statistics, Theory and Methods 45(12), 3612-3624.
14. Chakraborty S. (2015), Generating Discrete Analogues of Continuous Probability Distributions—A Survey of Methods and Constructions. J Stat Dist App. 2015; 2(1):
15. Hassan, A. and Ahmad, P. B. (2014): On Bayesian Estimation of Size-Biased Modified Power Series Distributions. Journal of Applied Statistical Science (USA), 20(3), 241-255.
16. Chakraborty S. (2010). On Some Distributional Properties of the Family of Weighted Generalized Poisson Distribution. Communications in Statistics - Theory and Methods, 39 (15), 2767-2788.
17. Hassan, A. and Ahmad, P. B. (2010): On the Bayes Estimators of the Parameters of Zero-Inflated Modified Power Series Distribution. Journal of Statistical Theory and Applications (USA), 9(3), 427-441.
18. Hassan, A. and Ahmad, P. B. (2009): Misclassified Size-Biased Modified Power Series Distribution and its applications. Mathematica Bohemica, 134(1), 1-17.
19. Hassan, A. and Ahmad, P. B (2009): Misclassification in Size-Biased Modified Power Series Distribution and its applications, Journal of the Korean Society for Industrial and Applied Mathematics (South Korea), 13(1), 55-72.
20. Hassan, A. and Ahmad, P.B. (2006): Application of Non-Zero Inflated Modified Power Series Distribution in Genetics, Journal of Probability and Statistical Science (Taiwan, Republic of China), 4(2), 195-205.
21. Angers, J. and Biswas, A. (2003): A Bayesian analysis o f zero-inflated generalized Poisson model. Computational Statistics and Data Analysis, 42, 37-46.
22. Consul, P. C. (1989). Generalized Poisson distribution: Properties and Applications. New York: Marcel Dekker.
23. Consul, P. C., Famoye, F. (1988). Maximum likelihood estimation for the generalized Poisson distribution when sample mean is larger than sample variance. Communications in Statistics: Theory and Methods 17(1):299–309.
24. Gupta, R.D and Kundu, D. (2000): Generalized exponential distribution: different method of estimations, Journal of Statistical Computation and Simulation, 1-22.
25. Gupta, R.D and Kundu, D. (2004): Discriminating between gamma and generalized exponential distributions Journal of Statistical Computation and Simulation, 74(2), 107-121.
26. Khodabina, M. and Ahmadabadi ,A. (2010): Some properties of generalized gamma distribution, Mathematical Sciences, 4(1), 9-28.

**Course Title: Advanced Regression Theory**

**Course Code: STA905E**

**Credits: 4**

**Marks: 100**

**Unit I:**

Linear Models, Assumptions and diagnostics, Model specification and interpretation, Estimation and inference, Variance Inflation Factor (VIF), Heteroscedasticity, Cook's Distance, Outliers and influential observations. Partial and Global significance of the model. Transformations and model improvements based on residuals. Prediction of response with confidence limits. Diagnostic checks for suitability and validity of a linear model, graphical techniques, tests for normality, un-correlatedness, lack of fit. Gauss-Markov theorem, Multicollinearity and its impact on OLS estimators.

**Unit II:**

Fundamental concepts of Generalized Linear Model (GLM), Components of a GLM: linear predictor, link function, and response distribution. Understanding count data, Poisson regression model, Model interpretation and diagnostics. Overdispersion and Quasi-Poisson Regression, Negative binomial regression model, Model interpretation and comparison with Poisson regression, Zero-inflated Poisson regression, Zero-inflated negative binomial regression, Model interpretation and application, Model selection techniques for count regression models, Real-world applications of count regression models.

**Unit III:**

GLMs for Binary response, log-odds and odds ratios, logistic regression. Logit, complementary log-log and probit transformations. Extending logistic regression to multiple categories, model interpretation and comparison. Concept of deviancy, suitability of a binary model by using analysis of deviancy and by examining the significance of parameters, Pearson and deviancy residuals, statistical tests for acceptability of a fitted model; Pearson's chi square test and likelihood ratio test.

**Unit IV:**

Introduction to parametric survival models, Exponential, Weibull, Log-logistic, Log-normal, Gamma distributions, Fitting parametric models to survival data. Partial likelihood and estimation of regression coefficients and their standard errors. Residuals and model checking under parametric models. Wald, Rao and likelihood tests for model coefficients. Comparing two or more survival models. Hazard and Survival plots. Testing proportional hazards hypothesis in the

Weibull model of cumulative incidence function. Model selection criteria and comparison of nested models (-2logL and AIC). Real-world applications of parametric survival models in healthcare and engineering.

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