Central University of Punjab, Bathinda

Course Scheme & Syllabus
for
Ph. D. Course Work
in
Statistics

Department of Mathematics and Statistics
School of Basic and Applied Sciences

Course structure for Ph.D. Course work in Statistics

Program Outcomes:

Learners will be able to

- develop a broad understanding of recent theories, tools and techniques in research areas of Mathematics
- enable to be competent to apply various Mathematical techniques in variety of situations
- enable to independently develop and plan research in various areas of mathematics and allied areas.

Structure for course work for PhD in Statistics

S. No.	Subject Code	Subject Name	Courses	Hours			Credits
				L	T	P	
1.	STA.701	Research Methodology	Core	2	0	0	2
2.	STA.702	Computer Applications	Core	2	0	0	2
3.	STA.703	Review Writing and Seminar	Core	0	0	0	2
4.	MAT.751	Research and Publication Ethics	Core	2	0	0	2
Opt any two out of the following elective courses offered							
5.	STA.705	Fractional Calculus	DE	4	0	0	4
6.	STA.706	Advanced Probability Theory	DE	4	0	0	4
7.	STA.707	Stochastic Processes and Queuing Theory	DE	4	0	0	4
8.	STA.708	Reliability Theory	DE	4	0	0	4
9.	STA.709	Statistical Methods for Insurance	DE	4	0	0	4
10.	STA.710	Stochastic Finance and Machine Learning in Insurance	DE	4	0	0	4
						Total Credits	**16**

Syllabi for Ph. D. Course work

Course Title: Research Methodology
Course Code: STA.701
Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning outcomes:.
Upon successful completion of this course, the student will be able to:

1. Understand meaning, objectives, characteristics, significance, and types of research.
2. Understand the different steps of formulation of research problem.
3. Use latex to write different type of reports.
4. Understand the basics of different bibliography/reference preparation styles.

Unit-I **8 Hours**

Introduction: Meaning, Objectives, Characteristics, Significance, and Types of Research.

Formulating Research Problem: Understanding a Research Problem, Selecting the Research Problem, Steps in Formulation of a Research Problem, Formulation of Research Objectives, and Construction of Hypothesis.

Unit-II **8 Hours**

Installation of the software LaTeX, Understanding LaTeX compilation and LaTeX editors, Basic syntax, Writing mathematical equations, Matrices, Tables, Inclusion of graphics into LaTeX file.

Page configurations: Title, Abstract, Keywords, Chapter, Sections and Subsections, References and their citations, Labeling of equations, Table of contents, List of figures, List of tables, Page numbering, Generating index.

Unit-III **7 Hours**

Packages: amsmath, amssymb, amsthm, amsfonts, hyperrefer, graphic, color, xypic, latexsym, natbib, setspace, multicol, subcaption, url, verbatim, tikz, and geometry.

Classes: Article, Report, Book, Letter, Slides, Beamer.

Unit-IV **7 Hours**

Report Writing: Types of Reports – Technical and Popular Reports, Significance of Report Writing, Different Steps in Writing Report, Art of Writing Research Proposals, Research Papers, Project Reports, and Dissertations/Thesis; Basics of Citation and Bibliography/Reference Preparation Styles; Report Presentation: Oral and Poster Presentations of Research Reports.

Suggested Readings:

1. Kothari, C.R. and G. Garg (2014): *Research Methodology*: Methods and Techniques, 3rd ed., New Age International Pvt. Ltd. Publisher
2. Kumar, R. (2014): *Research Methodology – A Step-By-Step Guide for Beginners*, 4th ed., Sage Publications
3. J. Anderson, *Thesis and Assignment Writing*, 4th ed., Wiley, USA, 2001.
4. Catherine Dawson, *Practical Research Methods,* New Delhi, UBS Publishers' Distributors, 2014.
5. L. Lamport. LATEX: A Document Preparation System, User's Guide and Reference Manual. 2nd Edition, Addison Wesley, New York, 1994.
6. Copyright Protection in India [website: http:copyright.gov.in].
7. World Trade Organization [website: www.wto.org].

Course Title: Computer Applications
Course Code: STA.702
Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

1. Use different operating system and their tools easily.
2. Use word processing software, presentation software, spreadsheet software and latex.
3. Understand networking and internet concepts.
4. Use computers in every field like teaching, industry and research.

Course Contents

UNIT I **Hours: 8**

Computer Fundamentals: Introduction to Computer, Input devices, Output Devices, Memory (Primary and Secondary), Concept of Hardware and Software, C.P.U., System bus, Motherboard, Ports and Interfaces, Expansion Cards, Ribbon Cables, Memory Chips, Processors, Software: Types of Software, Operating System, User Interface of popular Operating System, Introduction to programming language, Types of Computer.

UNIT II **Hours: 7**

Computer Network: Introduction to Computer Network, Types of Network: LAN, WAN and MAN, Topologies of Network, Internet concept, WWW.

Word Processing: Text creation and Manipulation; Table handling; Spell check, Hyper-linking, Creating Table of Contents and table of figures, Creating and tracking comments, language setting and thesaurus, Header and Footer, Mail Merge, Different views, Creating equations, Page setting, Printing, Shortcut keys.

UNIT III **Hours: 8**

Presentation Tool: Creating Presentations, Presentation views, working on Slide Transition, Making Notes Pages and Handouts, Drawing and Working

with Objects, Using Animations, Running and Controlling a Slide Show, Printing Presentations, and Shortcut keys.
Spread Sheet: Entering and editing data in cell, Basic formulas and functions, deleting or inserting cells, deleting or inserting rows and columns, printing of Spread Sheet, Shortcut keys.

UNIT IV **Hours: 7**

Use of Computers in Education and Research: Data analysis tools, e-Library, Search engines related to research, Research paper editing tools like Latex.

Transactional Modes:

PPT
Video
e-content
google drive

Suggested Readings:

Sinha, P.K. Computer Fundamentals. BPB Publications.
Goel, A., Ray, S. K. 2012. Computers: Basics and Applications. Pearson Education India.
Microsoft Office Professional 2013 Step by Step https://ptgmedia.pearsoncmg.com/images/9780735669413/samplepages/97807356694 13.pdf

Course Title: Review Writing and Presentation
Course Code: STA.703
Total Hours: 60

L	T	P	Cr
0	0	4	2

Learning outcomes:.

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

1. Understand the aspects of the Review writing and seminar presentation..
2. Write a review of existing scientific literature with simultaneous identification of knowledge gaps.
3. Identify the predatory publications and open access publications.

The evaluation criteria for "Review Writing and Presentation" shall be as follows:

S. No.	Criteria	Marks
1.	Literature review report	20
2.	Content of presentation	10
3.	Presentation Skills	10
4.	Handling of queries	10
Total		**50**

Course Title: Research and Publication Ethics
Course Code: MAT.751
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Learning outcomes:.
Upon successful completion of this course, the student will be able to:
1. Understand the philosophy and value of publication ethics.
2. Understand ethics with respect to science and research.
3. Identify the predatory publications and open access publications.
4. Use different software and their tools to check plagiarism check.

Unit-I **8 hours**

PHILOSOPHY AND ETHICS: Introduction to philosophy definition, nature and scope, concept, branches ; Ethics definition, moral of moral judgements and reactions.

SCIENTIFIC CONDUCT: Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts Falsification, Fabrication, and plagiarism (FFP); Redundant publication duplicate and overlapping publication, salami slicing; Selective reporting and misrepresentation of data

Unit-II **7 Hours**

PUBLICATION ETHICS: Publication ethics definition introduction and importance; Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types; violation of publication ethics , authorship and contributor ship; identification of publication misconduct, complaints and appeals; predatory publishers and journals

Unit-III **8 hours**

OPEN ACCESS PUBLISHING: Open access publication and initiatives; SHERPA/Ro MEO online resource to check publisher copyright & self-archiving policies; software tool to identify predatory publications developed by SPPU; journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

PUBLICATION MISCONDUCT:

A. Group Discussions : a) Subject specific ethical issues, FFP, authorship; b) Conflicts of interest; c) Complaints and appeals: examples and fraud from India and abroad

B. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Unit-IV **7 Hours**

DATABASES AND RESEARCH METRICS:

A. Databases : a) Indexing databases; b) Citation databases: web of Science, Scopus, etc.

B. Research Metrics: a) Impact Factor of journal as per journal Citation Report, SNIP, SJR, IPP, Cite Score b) Metrics, h-index, g-index, i10 index, altmetrics

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning/Practical.

Suggested Readings:

1. Melville, S., and Goddad, W. (1996). Research Methodology: An Introduction to Science and Engineering students. South Africa: Juta Academic.
2. Kothari, C.R. and G. Garg (2014): *Research Methodology*: Methods and Techniques, 3rd ed., New Age International Pvt. Ltd. Publisher.

Course Title: Fractional Calculus
Course Code: STA.705
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning outcomes:.
Upon successful completion of this course, the student will be able to:
1. learn the basics of fractional calculus.
2. know the basics of fractional differential equations.
3. Learn the different types of fractional derivatives
3. Understand the concept of linear fractional differential equations.
4. apply different techniques for solving fractional differential equations

Unit I **16 Hours**

Special Functions of Fractional Calculus: Gamma function, Some properties of Gamma function, Beta function, Contour integral representation. Fractional derivatives and integrals, GrunwaldLetnikov Fractional derivatives, Riemann-Liouville fractional derivatives, Caputo's fractional derivative, The Leibniz rule for fractional derivatives, Geometric and physical interpretation of fractional integration and fractional differentiation.

Unit II **14 Hours**

Sequential fractional derivatives. Left and right fractional derivatives. Properties of fractional derivatives. Laplace transforms of fractional derivatives. Fourier transforms of fractional derivatives. Mellin t ransforms of fractional derivatives.

Unit III **15 Hours**

Linear Fractional Differential Equations: Fractional differential equation of a general form. Existence and uniqueness theorem as a method of solution. Dependence of a solution on initial conditions. The Laplace transform method. Standard fractional differential equations. Sequential fractional differential equations.

Unit IV **15 Hours**

Fractional Differential Equations: Introduction, Linearly independent solutions, Solutions of the homogeneous equations, Solution of the non-homogeneous fractional differential equations, Reduction of fractional differential equations to ordinary differential equations. Semi differential equations

Suggested Readings:

1. K. B. Oldham & J. Spanier, *The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order*, Dover Publications Inc, 2006.
2. K. S. Miller & B. Ross., *An Introduction to the Fractional Calculus and Fractional Differential Equations Hardcover*, Wiley Blackwell, 1993.
3. I. Podlubny, *Fractional Differential Equations*, Academic Press, 1998.

Course Title: Advanced Probability Theory
Course Code: STA.706
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes: At the end of the course the students will be able to

- Understand the concept of sigma field, probability measure and probability space.
- Explore the concept of distribution and random variables.
- Understand the concept of WLLN and SLLN.
- Apply the use of conditional expectation in real applications.
- Learn the concept of convergence of sequences of random variables.

Unit I **16 Hours**

Fields, sigma-fields, measurable functions, measures, Lebesgue measure, distribution functions, coin-tossing, abstract integration. Probability spaces, random variables, expectation, inequalities

Unit II **14 Hours**

Independence of random variables, Weak law of large numbers, Bernstein's theorem, Borel-Cantelli lemmas, 4^{th} moment Strong law of large numbers, Borel-Cantelli Lemma, Kolmogorov zero-one law.

Unit III **14 Hours**

Various modes of convergence of sequences of random variables (in probability, almost surely, in rth mean), Implication between modes of convergence. Slutsky's theorem. Demoivre Laplace central limit theorem, Liapounovs and Lindeberg's central limit theorem.

Unit IV **16 Hours**

Conditional expectation. Some real data instances of theory. Definition and examples of martingales. Doob decomposition, martingale transforms, stopping times. Brownian motion. Existence and path continuity. Invariance

properties. Path non-differentiability. Associated martingales and their use in finding distributions.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching /Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. K. L. Chung, A Course in Probability Theory, 3rd Edition, Academic Press, 2001.
2. P. Billingsley, Probability and Measure, 3rd Edition, Wiley Series in Probability and Mathematical Statistics. 2008.
3. P. L. Meyer, Introductory Probability and Statistical Applications, 2nd Edition, Oxford & Lbh, 2017.
4. S. M. Ross, Introduction to Probability Models, 11th Edition, 2014.
5. V. K. Rohtagi and A. K. M. E. Saleh, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, 2010.

Course Title: Stochastic Processes and Queuing Theory
Course Code: STA.707
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes: The students will be able to

- Explain Stochastic Processes.
- Classify among various forms of stochastic processes.
- Make use of random walk and counting process.
- Justify Discrete-time queues.
- Justify Markov Chains
- Discuss Renewal and elementary renewal process.
- Discuss Simulation of queues and queuing networks.

Unit I **15 Hours**

Review of probability, Random variables and distributions, Generating functions and transforms; Stochastic processes, Discrete and continuous-time Markov chains, Renewal processes,

Unit II **15 Hours**

Brownian motion; Characteristics of queueing systems, Little's formula, Markovian and non-Markovian queueing systems, Embedded Markov chain applications to M/G/1, G/M/1, and related queueing systems,

Unit III **15 Hours**

Queues with vacations, Priority queues, Queues with modulated arrival process, Discrete-time queues and matrix-geometric methods in queues; Networks of queues, Open and closed queueing networks,

Unit IV **15 Hours**

Algorithms to compute the performance metrics; Simulation of queues and queueing networks; Application to manufacturing, Computer and communication systems and networks.

Suggested Readings:

1. L. Kleinrock, *Queueing Systems*, Vol. 1: Theory, 1975, Vol. 2: Computer Applications, 1976, John Wiley and Sons.
2. J. Medhi, *Stochastic Models in Queueing Theory* (2nd Edition),, Academic Press, 2002.
   S. Asmussen, *Applied Probability and Queues* (2nd Edition),, Springer, 2003.
3. D. Gross, and C.Harris, *Fundamentals of Queueing Theory*, 3rd Edition, John Wiley and Sons, 1998.
4. R.B. Cooper, *Introduction to Queueing Theory* (2nd Edition), North-Holland, 1981.
5. R. Nelson, Probability, *Stochastic Processes, and Queueing Theory: The Mathematics of Computer Performance Modelling*, Springer-Verlag, 1995.
6. E. Gelenbe, and G. Pujolle, *Introduction to Queueing Networks* (2nd Edition), John Wiley, 1998.

Course Title: Reliability Theory
Course Code: STA.708
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning outcomes: The students will be able to

- Understand the concept of population theories.
- Explain stochastic models for reproduction.
- Explain different measures of mortality.
- Discuss stochastic models for migration.
- Get in-depth understanding of methods for population projection.

Unit I **15 Hours**

Reliability Concepts and Measures: Components and systems, Coherent systems, Reliability of coherent systems, Cuts and paths, Modular decomposition, Bounds on system reliability, Structural and reliability importance of components.

Unit II **15 Hours**

Life distributions and associated survival, Conditional survival and hazard rate functions. Exponential, Weibull, Gamma life distributions and estimation of their parameters.

Unit III **15 Hours**

Notions of ageing. IFR IFRA, NBU, DMRL, NBUE, and HNBUE classes; their duals and relationships between them. Closures of these classes under formation of coherent systems, convolutions and mixtures.

Unit IV **15 Hours**

Partial orderings: Convex, star, stochastic, failure rate and mean-residual life orderings. Univariate shock models and life distributions arising out of them. Maintenance and replacement policies, Availability of repairable systems.

Suggested Readings:

1. R. E. Barlow and F. Proschan, *Statistical Theory of Reliability and Life Testing,* Holt, Rinehart and Winston, 1985.
2. J. F. Lawless, *Statistical Models and Methods of Life Time Data*, John Wiley Models, Marcel Dekker, 1982.
3. M. Shaked and J. G. Shanthikumar, *Stochastic Orders & Their Applications*, Academic Press, 1994.

Course Title: Statistical Methods for Insurance
Course Code: STA.709
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes: The students will be able to

- Understand the concept of Insurance.
- Explain Insurance contracts.
- Classify insurance in life and non-life insurance.
- Discuss ruin theory.
- Get in-depth understanding of Bayesian inference and credibility theory.

Unit I **16 Hours**

Origin, Development and Present Status of Insurance, Risk Management, List out the Benefit and Cost of Insurance, Fundamental Key Principles of Insurance, Types of Insurance Contracts, Classification of Insurance. Classification of insurance in life and non-life insurance, micro insurance, social insurance and general insurance (motor, marine, fire, miscellaneous), Types of insurance plans: whole life, term, endowment.

Unit II **14 Hours**

Review of Loss distributions: Classical loss distributions, heavy-tailed distributions, reinsurance and loss distributions. Reinsurance and effect of inflation. Risk models for aggregate claims: Collective risk model and individual risk model, premiums and reserves for aggregate claims, reinsurance for aggregate claims.

Unit III **14 Hours**

Ruin theory: Surplus process in discrete time and continuous time, probability of ruin in finite and infinite time, adjustment coefficient, Lundberg inequality, applications in reinsurance.

Unit IV **16 Hours**

Types of investments and saving, Insurance, Shares, Bonds, Annuities, Mutual and Pension Fund. Introduction to Bayesian inference, Credibility Theory, Full credibility for claim frequency, claim severity and aggregate loss. Bayesian credibility, Empirical Bayes credibility.

Suggested Readings:

1. D. C. M. Dickson, *Insurance Risk and Ruin*, Cambridge University Press, Cambridge,2005.
2. E. S. Harrington and R. Gregory, *Risk Management and Insurance*: 2nd ed., Tata McGraw Hill Publicating Company Ltd. New Delhi,1998.
3. J. Grandell, *Aspects of Risk Theory*, Springer-Verlag, New York, 1990.
4. N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones, and C. J. Nesbitt, *Actuarial Mathematics*, Second Edition, The Society of Actuaries. Sahaumburg, Illinois, 1984.
5. P. J. Boland, *Statistical and Probabilistic Methods in Actuarial Science*. Chapman & Hall, London, 2007.
6. S. Ramasubramanian, *Lectures on Insurance Models*, Hindustan Book Agency Texts and Readings in Mathematics, 2009.
7. T. Mikosch, *Non-Life Insurance Mathematics- An Introduction with a Poisson Process*, Springer, Berlin, 2004.

Course Title: Stochastic Finance and Machine Learning in Insurance
Course Code: STA.710
Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes: The students will be able to

- Understand the mechanism of options markets.
- Explain Brownian motion and Weiner Process.
- Explain Black- Scholes Model.
- Discuss various forms of Clustering.
- Get in-depth understanding of Ensembling methods.

Unit I **16 Hours**

Mechanism of Options markets, Types of Options, Option positions, Derivatives, Underlying Assets, Specification of stock options, Stock option pricing, Factors affecting option prices, Upper and lower bounds for option prices, Trading strategies involving options, Binomial model: One-step and two-step models, Binomial trees. Risk neutral valuation.

Brownian Motion, Weiner Process, Quadratic Variation, Arithmetic and Geometric Brownian motion, Review of basic properties and related martingales, Applications to insurance problems, Ito Lemma, Ito integral, Applying Ito Lemma.

Unit II **14 Hours**

Black-Scholes model: Distribution of rate of returns, volatility, risk neutral pricing, Discrete and Continuous Martingale pricing, Idea underlying the

Black-Scholes-Merton differential equation, Estimating volatilit

Unit III **14 Hours**

Basics: Introduction to Machine Learning - Different Forms of Learning Classification: Classification tree, SVM, Instance Based Classification, LDA, Multiclass Classification.
Clustering: Partitional Clustering - K-Means, K-Medoids, Hierarchical Clustering-Agglomerative, Divisive, Distance Measures, Density Based Clustering – DBscan, Spectral Clustering

Unit IV **16 Hours**

Ensemble Methods: Boosting - Adaboost, Gradient Boosting, Bagging - Simple Methods, Random Forest
Dimensionality Reduction: Multidimensional Scaling, and Manifold Learning Reinforcement Learning: Q-Learning, Temporal Difference Learning

Suggested Readings

1. C. Bishop, *Pattern Recognition and Machine Learning*. Springer, 2010.
2. E. S. Steven, *Stochastic Calculus for Finance I: The Binomial Asset Pricing Models*, Springer, 2005.
3. J. C. Hull and S. Basu, *Options, Futures and Other Derivatives*, 3rd Prentice hall of India Private Ltd., New Delhi, 2010.
4. J. Han and M. Kamber, *Data Mining: Concept and Techniques,* 3rd Edition,Elsevier, USA, 2012.
5. M. S. Joshi, *The Concept and Practice of Mathematical Finance*, 2nd Edition, Cambridge University Press, 2008.
6. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification,* 2nd edition,Wiley-Blackwell, 2000.
7. S. M Ross, *An Elementary Introduction to Mathematical Finance*, Cambridge University Press, 2005.
8. T. Hastie, R. Tibshirani and J. Friedman, *Elements of Statistical Learning*, 9th Edition, Springer, 2017.
9. T. Mitchell, *Machine Learning*. Mc-Graw Hill, 2017.