

Central University of Punjab



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

**Department of Mathematics and Statistics School of
Basic Sciences**

(Batch: 2025-26)

Course work structure for Ph.D. in Statistics

Students can move into the Ph.D. programme after successful completion of Ph. D. Course work during the first two semesters, provided they meet the requirements specified by the university.

Graduate Attributes:

Learners will be able to develop a broad understanding of recent theories, tools and techniques in different research areas of Statistics. They will be well prepared and competent to apply various Statistical techniques in a variety of situations. They will be able to independently develop and plan research in various areas of statistics and allied areas. They will be well prepared to avail teaching and research job opportunities in the reputed institutes of India and abroad.

	Semester I						
	S. No.	Subject Code	Subject Name	Credit Hours			Course Credits
				L	T	P	
Compulsory Courses	1.	STA.701	Research Methodology	2	0	0	2
	2.	STA.702	Computer Applications	2	0	0	2
	3.	MAT.751	Research and Publication Ethics	2	0	0	2
	4.	STA.752	Teaching Assistantship	0	0	2	1
	5.	UNI.753	Curriculum, Pedagogy and Evaluation	1	0	0	1
Opt any two out of the following							
Elective Courses	6.	STA.704	Fractional Calculus	4	0	0	4
	7.	STA.705	Advanced Probability Theory	4	0	0	4
	8.	STA.706	Stochastic Processes and Queuing Theory	4	0	0	4
	9.	STA.707	Reliability Theory	4	0	0	4
	10.	STA.708	Statistical Methods for Insurance	4	0	0	4
	11.	STA.709	Stochastic Processes in Finance	4	0	0	4
	12.	STA.710	Foundation of Machine Learning	4	0	0	4
	13.	MAT.715	Advance Linear Algebra	4	0	0	4
	Total Credits						16

Course Title: Research Methodology

Course Code: STA.701

Total Hours: 30

L	T	P	Credits
2	0	0	2

Learning outcomes:

The student will be able to:

CLO1: Understand meaning, objectives, characteristics, significance, and types of research.

CLO2: Understand the different steps of formulation of research problems.

CLO3: Use latex to write different types of reports.

CLO4: Understand the basics of different bibliography/reference preparation styles.

UNIT/Hours	Content	Mapping with CLO
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.	CLO1 CLO2
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.	CLO3
Unit-II/7 Hours	Packages: amsmath, amssymb, amsthm, amsfonts, hyperrefer, graphic, color, xypic, latexsym, natbib, setspace, multicol, subcaption, url, verbatim, tikz, and geometry. Classes: Article, Report, Bresearchhook, Letter, Slides, Beamer.	CLO3

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. TRANSACTION MODE: Lecture/Demonstration/Project Method/Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.	CLO4
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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	Credits
2	0	0	2

Learning Outcomes:

The student will be able to:

CLO1: Use different operating systems and their tools easily.

CLO2: Use word processing software, presentation software, spreadsheet software and latex.

CLO3: Understand networking and internet concepts.

CLO4: Use computers in every field like teaching, industry and research.

UNIT/Hours	Content	Mapping with CLO
UNIT I/8 Hours	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.	CLO1
UNIT II/7 Hours	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.	CLO2
UNIT III/8 Hours	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. Spreadsheet: Entering and editing data in cell, Basic formulas and functions, deleting or inserting cells, deleting or inserting rows and columns, printing of SpreadSheet, Shortcut keys.	CLO3
UNIT	Use of Computers in Education and Research: Data analysis	CLO4

IV/7 Hours	tools, e-Library, Search engines related to research, Research paper editing tools like Latex. Transactional Modes: PPT Video e-content google drive	
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Suggested Readings:

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

Course Title: Research and Publication Ethics

Course Code: MAT.751

Total Hours: 30

L	T	P	Credits
2	0	0	2

Learning outcomes:

The student will be able to:

CLO1: Understand the philosophy and value of publication ethics.

CLO2: Understand ethics with respect to science and research.

CLO3: Identify the predatory publications and open access publications.

CLO4: Use different software and their tools to check plagiarism.

UNIT/Hours	Content	Mapping with CLO
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	CLO1
II	PUBLICATION ETHICS: Publication ethics definition	CLO2

7 Hours	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 contributorship; identification of publication misconduct, complaints and appeals; predatory publishers and journals	
III 8 Hours	OPEN ACCESS PUBLISHING: Open access publication and initiatives; SHERPA/RoMEO 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.	CLO3
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	CLO4

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: Teaching Assistantship

Total Hours: 30

Course Code: STA.752

L	T	P	Credits
0	0	2	1

Learning Outcome:

At the end of this skill development course, the scholars shall be able to

CLO 1: familiarize themselves with the pedagogical practices of effective classroom delivery and knowledge evaluation system

CLO 2: manage large and small classes using appropriate pedagogical techniques for different types of content

Activities and Evaluation:

- The scholars shall attend Master degree classes of his/her supervisor to observe the various transaction modes that the supervisor follows in the classroom delivery or transaction process one period per week.
- The scholars shall be assigned one period per week under the direct supervision of his/her supervisor to teach the Master degree students adopting appropriate teaching strategy(s).
- The scholars shall be involved in the examination and evaluation system of the Master degree students such as preparation of questions, conduct of examination and preparation of results under the direction of the supervisor.
- At the end of the semester, the supervisor shall conduct an examination of teaching skills learned by the scholar as per the following **evaluation criteria**:
 - The scholars shall be given a topic relevant to the Master degree course of the current semester as his/her specialization to prepare lessons and deliver in the classroom before the master degree students for one hour (45 minutes teaching + 15 minutes interaction).
 - The scholars shall be evaluated for a total of 50 marks comprising *content knowledge* (10 marks), *explanation and demonstration skills* (10 marks), *communication skills* (10 marks), *teaching techniques employed* (10 marks), and classroom interactions (10).

Course Title: CURRICULUM, PEDAGOGY AND EVALUATION**Course Code: UNIV.753****Total Hours: 15**

L	T	P	Credits
1	0	0	1

Learning outcomes:

After completion of the course, scholars shall be able to:

CLO1: analyze the principles and bases of curriculum design and development

CLO2: examine the processes involved in curriculum development

CLO3: develop the skills of adopting innovative pedagogies and conducting students' assessment

CLO4: develop curriculum of a specific course/programme

UNIT/Hours	Content	Mapping with CLO
I 4 Hours	Bases and Principles of Curriculum 1. Curriculum: Concept and Principles of curriculum development, Foundations of Curriculum Development. Types of Curriculum Designs- Subject centered, learner centered, experience centered and core curriculum. Designing local, national, regional and global specific curriculum. Choice Based Credit System and its implementation.	CLO1
II 4 Hours	Curriculum Development 3. Process of Curriculum Development: Formulation of graduate attributes, course/learning outcomes, content selection, organization of content and learning experiences, transaction process. Comparison among Interdisciplinary, multidisciplinary and trans-disciplinary approaches to curriculum.	CLO2
III	Curriculum and	CLO3

3 Hours	Pedagogy - Conceptual understanding of Pedagogy. - Pedagogies: Peeragogy, Cybergogy and Heutagogy with special emphasis on Blended learning, Flipped learning, Dialogue, cooperative and collaborative learning Three e- techniques: Moodle, Edmodo, Google classroom	
IV 4 Hours	Learners' Assessment - Assessment Preparation: Concept, purpose, and principles of preparing objective and subjective questions. - Conducting Assessment: Modes of conducting assessment – offline and online; use of ICT in conducting assessments. Evaluation: Formative and Summative assessments, Outcome based assessment, and scoring criteria.	CLO4

Transaction Mode

Lecture, dialogue, peer group discussion, workshop

Evaluation criteria

There shall be an end term evaluation of the course for 50 marks for a duration of 2 hours. The course coordinator shall conduct the evaluation.

- Allyn, B., Beane, J. A., Conrad, E. P., & Samuel J. A., (1986). *Curriculum Planning and Development*. Boston: Allyn & Bacon.
- Brady, L. (1995). *Curriculum Development*. Prentice Hall: Delhi. National Council of Educational Research and Training.
- Deng, Z. (2007). Knowing the subject matter of science curriculum, *Journal of Curriculum Studies*, 39(5), 503-535. <https://doi.org/10.1080/00220270701305362>
- Gronlund, N. E. & Linn, R. L. (2003). *Measurement and Assessment in teaching*. Singapore: Pearson Education
- McNeil, J. D. (1990). *Curriculum: A Comprehensive Introduction*, London: Scott, Foreman/Little
- Nehru, R. S. S. (2015). *Principles of Curriculum*. New Delhi: APH Publishing Corporation.

- Oliva, P. F. (2001). *Developing the curriculum* (Fifth Ed.). New York, NY: Longman
- Stein, J. and Graham, C. (2014). *Essentials for Blended Learning: A Standards-Based Guide*. New York, NY: Routledge.

Web Resources

- https://www.westernsydney.edu.au/data/assets/pdf_file/0004/467095/Fundamentals_of_Blended_Learning.pdf
- <https://www.uhd.edu/academics/university-college/centers-offices/teaching-learning-excellence/Pages/Principles-of-a-Flipped-Classroom.aspx>
- <http://leerwegdialoog.nl/wp-content/uploads/2018/06/180621-Article-The-Basic-Principles-of-Dialogue-by-Renate-van-der-Veen-and-Olga-Plokhooij.pdf>

Course Title: Fractional Calculus

Course Code: STA.704

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning outcomes:

The student will be able to:

CLO1:. Learn the basics of fractional calculus.

CLO2:. Know the basics of fractional differential equations.

CLO3:. Learn the different types of fractional derivatives

CLO4:. Understand the concept of linear fractional differential equations.

CLO5:. Apply different techniques for solving fractional differential equations.

UNIT/Hours	Content	Mapping with CLO
I 15Hours	Special Functions of Fractional Calculus: Gamma function, Some properties of Gamma function, Beta function, Contour integral representation. Fractional derivatives and integrals, Grunewald Letnikov 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.	CLO1 & CLO2
II 15 Hours	Sequential fractional derivatives. Left and right fractional derivatives. Properties of fractional derivatives. Laplace transforms of fractional derivatives. Fourier transforms of fractional derivatives. Mellin transforms of fractional derivatives.	CLO3
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.	CLO4
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	CLO5

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.705

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes:

The students will be able to

CLO1: Understand the concept of sigma field, probability measure and probability space.

CLO2: Explore the concept of distribution and random variables.

CLO3: Understand the concept of WLLN and SLLN.

CLO4: Learn the concept of convergence of sequences of random variables.

CLO5: Apply the use of conditional expectation in real applications

UNIT/Hours	Content	Mapping with CLO
I 12 Hours	Fields, sigma-fields, measurable functions, measures, Lebesgue measure, distribution functions, coin-tossing, abstract integration. Probability spaces, random variables, expectation, inequalities	CLO1 & CLO2
II 12 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.	CLO3
III 11 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.	CLO4
IV 10 Hours	Conditional expectation. <u>Some real data instances of theory.</u> 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.	CLO5

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative

learning/Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/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.706

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes: The students will be able to CLO1:

Explain Stochastic Processes.

CLO2: Classify among various forms of stochastic processes.

CLO3: Make use of random walk and counting processes.

CLO4: Justify Discrete-time queues.

CLO5: Justify Markov Chains

CLO6: Discuss Renewal and elementary renewal process.

CLO7: Discuss Simulation of queues and queuing networks.

UNIT/Hours	Content	Mapping with CLO
I 15 Hours	Review of probability, Random variables and distributions, Generating functions and transforms; Stochastic processes, Discrete and continuous-time Markov chains, Renewal processes.	CLO1 & CLO2
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.	CLO3, CLO4 & CLO5

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,	CLO6
IV 15 Hours	Algorithms to compute the performance metrics; Simulation of queues and queueing networks; Application to manufacturing, Computer and communication systems and networks.	CLO7

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.707

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning outcomes:

The students will be able to

CLO1: Understand the concept of reliability theory.

CLO2: Explain life distribution and estimation of its parameters.

CLO3: Explain notions of ageing.

CLO4: Get in-depth understanding of methods for replacement policies.

UNIT/Hours	Content	Mapping with CLO
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.	CLO1
II 15 Hours	Life distributions and associated survival, Conditional survival and hazard rate functions. Exponential, Weibull, Gamma life distributions and estimation of their parameters.	CLO2 & CLO3
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.	CLO4
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.	CLO5

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

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.708

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes:

The students will be able to

CLO1: Understand the concept of Insurance.

CLO2: Explain Insurance contracts.

CLO3: Classify insurance in life and non-life insurance.

CLO4: Discuss ruin theory.

CLO5: Get in-depth understanding of Bayesian inference and credibility theory.

UNIT/Hours	Content	Mapping with CLO
I 15 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.	CLO1 & CLO2
II 15 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.	CLO3
III 15 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.	CLO4
IV 15 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.	CLO5

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

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 Publishing 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. Schaumburg, 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 Processes in Finance
Course Code: STA.709
Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes:

The students will be able to

CLO1: Understand the structure and mechanisms of financial derivatives and option markets.

CLO2: Analyze stochastic processes including Brownian motion and martingales.

CLO3: Apply stochastic calculus including Ito lemma and stochastic integrals.

CLO4: Develop and analyze option pricing models including binomial and Black–Scholes models.

CLO5: Evaluate advanced concepts such as risk-neutral pricing and volatility estimation.

UNIT/Hours	Content	Mapping with CLO
I 15 Hours	Introduction to financial derivatives: mechanism of options markets; types of options; option positions; underlying assets; specification of stock options; factors affecting option prices; bounds on option prices; trading strategies involving options; binomial model including one-step and two-step models; binomial trees; risk-neutral valuation.	CLO1
II 15 Hours	Stochastic processes for finance: Brownian motion and Wiener process; quadratic variation; arithmetic and geometric Brownian motion; martingales and their properties; applications to financial and insurance models.	CLO2 & CLO3
I 15 Hours	Stochastic calculus: Ito integral; Ito lemma and its applications; stochastic differential equations; applications of Ito calculus in financial modeling.	CLO4

IV 15 Hours	Option pricing models: Black–Scholes model; distribution of returns; volatility; risk-neutral pricing; discrete and continuous martingale pricing; derivation of Black–Scholes–Merton differential equation; estimation of volatility and model calibration.	CLO5
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TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.

Suggested Readings

1. E. S. Steven, *Stochastic Calculus for Finance I: The Binomial Asset Pricing Models*, Springer, 2005.
2. J. C. Hull and S. Basu, *Options, Futures and Other Derivatives*, 3rd Prentice hall of India Private Ltd., New Delhi, 2010.
3. M. S. Joshi, *The Concept and Practice of Mathematical Finance*, 2nd Edition, Cambridge University Press, 2008.
4. S. M Ross, *An Elementary Introduction to Mathematical Finance*, Cambridge University Press, 2005.

Course Title: Foundations of Machine Learning
Course Code: STA.710
Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning Outcomes:

The students will be able to

CLO1: Understand fundamentals of statistical learning, risk minimization, and generalization

CLO2: Analyze probabilistic models including Gaussian distributions, Bayesian inference, and stochastic processes.

CLO3: Analyze probabilistic models including Gaussian distributions, Bayesian inference, and stochastic processes.

CLO4: Implement and analyze supervised and unsupervised learning algorithms.

CLO5: Evaluate ensemble methods and reinforcement learning frameworks.

UNIT/Hours	Content	Mapping with CLO
I 15 Hours	Foundations: Introduction to Machine Learning; types of learning (supervised, unsupervised, reinforcement); statistical learning framework. Theory: Empirical Risk Minimization (ERM); bias-variance tradeoff; underfitting vs. overfitting; cross-validation and model selection. Linear Models & Classification: Linear and Logistic Regression; Decision Trees; Support Vector Machines (SVM); Linear Discriminant Analysis (LDA); Multiclass classification strategies (One-vs-Rest, One-vs-One). Clustering: K-means, K-medoids, Hierarchical clustering, Density-based clustering (DBSCAN), and Spectral clustering.	CLO1
II 15 Hours	Probability: Random variables, expectation, variance; Multivariate Gaussian distributions; Conjugate priors. Inference: Bayesian inference; Maximum Likelihood Estimation (MLE) and Maximum A Posteriori (MAP) estimation. Optimization: Geometry of objective functions; Convexity and Jensen's Inequality; Loss functions (Squared, Hinge,	CLO2 & CLO3

	Cross-entropy). Algorithms: Gradient Descent, Stochastic Gradient Descent (SGD), and Momentum-based methods; Newton's method.	
I 15 Hours	Ensemble Methods: Theory of Weak Learners; Bagging, Random Forests; Boosting (AdaBoost, Gradient Boosting, XGBoost/LightGBM basics). Dimensionality Reduction: The curse of dimensionality; Principal Component Analysis (PCA); Multidimensional Scaling (MDS); Manifold learning (t-SNE). Regularization: Lasso and Ridge regularization; Elastic Net; Dropout concepts and early stopping. Neural Foundations: Introduction to Perceptrons and Multi-Layer Perceptrons (MLP).	CLO4
IV 15 Hours	Framework: Markov Decision Processes (MDP); States, Actions, Rewards, and Transitions. Equations: Value functions (State and Action value); Bellman optimality equations. Algorithms: Policy evaluation and improvement; Temporal Difference (TD) learning; Q-learning and SARSA. Applications: Case studies in finance (portfolio optimization) and communication systems (resource allocation).	CLO5

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

Suggested Readings

1. C. Bishop, *Pattern Recognition and Machine Learning*. Springer, 2010.
2. J. Han and M. Kamber, *Data Mining: Concept and Techniques*, 3rd Edition, Elsevier, USA, 2012.
3. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification*, 2nd edition, Wiley-Blackwell, 2000.
4. T. Hastie, R. Tibshirani and J. Friedman, *Elements of Statistical Learning*, 9th Edition, Springer, 2017.
5. T. Mitchell, *Machine Learning*. Mc-Graw Hill, 2017.

Course Title: Advance Linear Algebra

Course Code: MAT.715

Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning outcomes:

The students will be able to

CLO1 Review the basic notions in linear algebra that are often used in mathematics and other sciences

CLO2 Define Vector spaces, Subspaces and related results.

CLO3 Define linear transformations and characteristic polynomials with examples.

CLO4 Illustrate various properties of canonical forms.

CLO5 Study of Inner product spaces

CLO6 Explain concepts of the Gram-Schmidt orthogonalization process.

Unit I 15 Hours	Vector spaces, Subspaces: Definition and Examples, Linear dependence and independence, Basis and dimensions, Coordinates, Linear transformations, Algebra of linear transformations, Isomorphism, Matrix representation of a linear transformation Activity: Students will construct different vector spaces like a set of all continuous functions, set of all polynomials. They will define Linear transformation on these spaces.	CLO1
Unit II 15 Hours	Change of basis, Rank and nullity of a linear transformation. Linear functionals, Dual spaces, Transpose of a linear transformation. Annihilating Polynomials: Characteristic polynomial and minimal polynomial of a linear transformation, Characteristic values and Characteristic vectors of a linear transformation, Cayley Hamilton theorem. Activity: Students will explore the geometrical and physical meaning of Characteristic values and characteristics vectors.	CLO2
Unit III 15 Hours	Diagonalizing matrices, Diagonalizing real symmetric matrices, Characteristic polynomials and minimal polynomials of block matrices, Canonical forms: Jordan canonical forms, rational canonical forms. Quotient spaces, Bilinear forms, Symmetric and skew- Symmetric bilinear forms, Sylvester's theorem, quadratic forms, Hermitian forms. Activity: Students will solve the problems related to applications of canonical forms of matrices.	CLO3
Unit IV 15 Hours	Inner product spaces. Norms and distances, Orthonormal basis, Orthogonality, Schwarz inequality, The Gram-Schmidt orthogonalization process. Orthogonal and positive definite matrices. Activity: Students will explore the application of defining norm and the inner product on vector spaces.	CLO4 CLO5 CLO6

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learning.

Suggested Readings:

1. J. Gilbert and L. Gilbert, *Linear Algebra and Matrix Theory*, Cengage Learning, 2004.
2. K. Hoffman and R. Kunze: *Linear Algebra*, 2nd Edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India, 2004.
3. V. Bist and V. Sahai, *Linear Algebra*, Narosa, Delhi, 2002.
4. S Lang, *Linear Algebra*, Undergraduate texts in mathematics, Springer, 1989.