



INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH
STOCHASTIC CALCULUS AND FINANCE

Course number	N/A
Course Title/Name	Stochastic Calculus and Finance
Course Level:	PG (i.e., PhD, MSc)
Semester	Jan to June 2025
Credits:	2 Credits TWELVE (12) session course (each session 1.5 hrs, i.e., total of EIGHTEEN (18) hrs)
Proposing Department	N/A
Other Department which may be interested	N/A
Instructor	Raghu Nandan Sengupta IME Dept, IIT Kanpur, INDIA, Email: raghus@iitk.ac.in
Prerequisites	<ul style="list-style-type: none">• Basic of (i) Probability & Statistics and (ii) Stochastic Processes or equivalent subjects• Basic (i) Accounting & Finance or (ii) Financial Management or equivalent subjects

Course Description/Syllabus

Part 1

Introduction of Stochastic Process; Ideas of State and Space (Discrete and Continuous); Random Walk, Markov Chain, Markov Process; Martingales, Branching Process; Binomial and Multinomial Pricing; Wiener Process; Stochastic Integrals; Stochastic Differential Equations and Itô's Lemma; Black-Schole's Model and its Derivation.

Part 2

Markowitz MV Model, CAPM, APT, Market Line, Measures of Risks, Derivatives, Forwards, Futures, Options, Swaps, Risk Neutral Pricing, Concepts of Hedging, Different ideas of Risk, KMV model, Credit Metrics, Introduction of Portfolio Analysis and Investment concepts, etc.

Objective

Application of the fundamental ideas of *Statistics* and *Stochastic Processes* in Finance are quite in-depth. Concepts from Statistics like Distributions, Sampling Distributions, Bayes Theorem, Conditional Distributions, EVD are heavily used in Finance. On the other hand, theories from Stochastic Processes like Random Walk, Markov Chain, Markov Process; Martingales, Binomial and Multinomial Pricing, Stochastic Integrals; Stochastic Differential Equations are also very popular and ubiquitous in the domain of finance. Students in this course will first pick up the core theory of the relevant topics from *Statistics* and *Stochastic Processes* and apply them in Investment Analysis, Risk Analysis, Derivatives, Risk Neutral Pricing, etc. They would also learn the fundamentals of Wiener



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Process, Stochastic Integrals, Stochastic Differential Equations, Itô's Lemma, Black-Schole's Model. This course will benefit students in their masters and doctoral programs and intending to work as researchers, teachers, financial data scientists, investment analysts, investment bankers, econometricians, etc.

Outcome/Key learning take away

- Will help students master the rich repertoire of tools for scientifically/rationally understanding quantitative finance.
- Will facilitate students with both the basic and advanced theoretical background in statistics and stochastic process which is needed in finance.
- Will equip learners with the requisite skills in utilizing different techniques through practical applications.
- Will help student with the use of a variety of statical and stochastic processes be it in investment banking, data analytics, financial budgeting, etc.

Requirement/Pre-requisites (Will be handled as required with extra sessions for students as required)

- 01) Probability and Statistics: Axioms of probability; Conditional probability; Discrete and continuous random variables; Functions of random variables; Moments of random variables; Generating functions; Limit theorems; Jointly distributed random variables; Sufficiency and completeness; Descriptive and inferential Statistics; Sampling theory and sampling distributions, Method for statistical inference; Theory of point estimation and estimation of parameters; Theory of interval estimation; Theory of hypotheses testing; Analysis of variance; Brief Introduction of Multivariate Analysis; Linear and multiple linear regression
- 02) Operations Research: Introduction Mathematical Modeling, Linear programming - Formulation, solution procedures, Duality, Sensitivity, Applications, Network methods - Max Flow, Min cost, Shortest path, Dynamic programming - Sequential decisions, Principle of optimality Applications Integer programming - Formulation, Nonlinear Programming - Applications and solution methods



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Contents/lan of classes (considering TWELVE (12) session course (each session 1.5 hrs, i.e., total of EIGHTEEN (18) hrs))

S No.	Coverage of Topics	Session #
01	Introduction of Stochastic Process; Ideas of State and Space (Discrete and Continuous); Random Walk, Markov Chain, Markov Process	01
02	-Do-	02
03	Martingales, Branching Process; Binomial and Multinomial Pricing	03
04	Wiener Process; Stochastic Integrals; Stochastic Differential Equations	04
05	Itô's Lemma; Black-Schole's Model and its Derivation	05
06	-Do-	06
07	Introduction of Portfolio Analysis and Investment concepts, Markowitz MV Model, CAPM, APT, Market Line	07
08	Measures of Risks, Derivatives, Forwards, Futures, Options, Swaps	08
09	-Do-	09
10	Risk Neutral Pricing, Concepts of Hedging, Different ideas of Risk	10
11	KMV model, Credit Metrics	11
12	-Do-	12

Evaluation Methodology

S No.	Evaluation Methods	Evaluation Criteria
01	Quizzes	30%
02	Project/Assignments	30%
03	End Semester examination	40%
Total		100%

References/Text books

Part 1

- 1) Ross, S. M., Introduction to Probability Models, Harcourt Indian Private Ltd., 2000, ISBN (10): 0-12-598475-8.
- 2) Ross, S. M. (1996), Stochastic Processes, John Wiley & Sons. ISBN: 0471120626.
- 3) Feller, W., An Introduction to Probability Theory and its Applications (Volume I), John Wiley & Sons, 2000, ISBN (10): 9971-51-315-3.
- 4) Feller, W., An Introduction to Probability Theory and its Applications (Volume II), John Wiley & Sons, 2000, ISBN (10): 9971-51-298-X.



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- 5) Shreve. S, Stochastic Calculus for Finance: I (The Binomial Asset Pricing Model), Springer, 2005, ISBN: 978-0387249681
- 6) Shreve. S, Stochastic Calculus for Finance: II (Continuous-Time Models), Springer, 2004, ISBN: 978-1441923110

Part 2

- 1) Modern Portfolio Theory and Investment Analysis; Edwin J. Elton and Martin J. Gruber, John Wiley & Sons.
- 2) Options, Futures and Other Derivatives; John C. Hull, Pearson Education Asia.
- 3) Risk Management and Financial Institutions; John C. Hull, Pearson Education, 2007.

Extra References

Part 1

- 1) Bhattacharya, R. N. and Waymire, E. C. (1990), Stochastic Processes with Applications, Wiley Interscience. ISBN: 0471842729.
- 2) Cox, D. R. and Miller, H. D. (1970), The Theory of Stochastic Processes, Methuen & Co. Ltd. ISBN: 0412151707.
- 3) Feller, W. (1968), An Introduction to Probability Theory and its Applications, Volume 1 & II, John Wiley. ISBN: 9780471257080 & 9780471257097.
- 4) Karlin, K. and Taylor, H. M. (1975), A First Course in Stochastic Processes, Academic Press. ISBN: 0-12-398552-8.
- 5) Karlin, K. and Taylor, H. M. (1981), A Second Course in Stochastic Processes, Academic Press. ISBN: 0-12-398650-8.

Part 2

- 1) Security Analysis and Portfolio Management; Donald E. Fischer and Ronald J. Jordan, Prentice Hall of India.
- 2) Investments; William F. Sharpe, Gordon J. Alexander and Jeffery V. Bailey, Prentice Hall of India.



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- 3) Investment Analysis and Portfolio Management; Prasanna Chandra, Tata McGraw Hill.
- 4) Investment Science; David G. Luenberger, Oxford University Press.
- 5) The Fundamental of Risk Measurement, Chris Marrison, Tata McGraw Hill, 2005
- 6) Quantitative Risk Management: Concepts, Techniques, and Tools; A. J. McNeil, R. Frey and P. Embrechts, Princeton University Press.
- 7) Risk Management: A Modern Perspective; Michael K. Ong (Edited), Academic Press, Elsevier.
- 8) Managing Credit Risk: The Next Great Financial Challenge; John B. Caouette, Edward I. Altman and Paul Narayanan, John Wiley & Sons, Inc.
- 9) Risk Aversion and Portfolio Choice; Donald J. Hester and James Tobin (Edited), Cowles Foundation for Research in Economics at Yale University (Monograph 19).
- 10) Advanced Credit Risk Analysis; Didier Cossin and Hugues Pirotte, John Wiley & Sons, Limited.
- 11) Risk Management in Banking; Joel Bessis, John Wiley & Sons, Limited.
- 12) Handbook of Management under Uncertainty; Jaime Gil-Aluja (Edited), Kluwer Academic Publishers.
- 13) Derivatives and Internal Models; Hans-Peter Deutsch, Palgrave Publishers.
- 14) Credit Risk Measurement: New Approaches at Value at Risk and other paradigms, Anthony Saunders and Linda Allen, John Wiley & Sons, Inc.
- 15) Algorithms for Worst-case Design and Applications to Risk Management; Berc Rustem and Melendres Howe, Princeton University Press.
- 16) Global Risk Management: Financial, Operational, and Insurance Strategies (International Finance Review Volume 3); J. Jay Choi and Michael R. Powers (Edited), JAI An imprint of Elsevier Science.
- 17) Applied Risk Analysis: Moving Beyond Uncertainty in Business; Jonathan Munn, John Wiley & Sons, Inc.
- 18) Measuring and Controlling Interest Rates and Credit Risk; Frank J. Fabozzi, Steven V. Mann and Moorad Choudhury, John Wiley & Sons, Inc.



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- 19) Credit Risk: Pricing Measurement and Management; Darrell Duffie and Kenneth J. Singleton, New Age International Publishers, India.
- 20) Credit Risk Modeling: Theory and Applications; David Lando, New Age International Publishers, India.
- 21) Mathematical Techniques in Finance: Tools for Incomplete Markets; Ales Cerny, New Age International Publishers, India.

Signature:

Date: 05-Mar-2025