| LNMIIT, Jaipur<br><br>Department of Mathematics | LNMIIT<br>The LNM Institute of Information Technology |
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| **Programme:**<br><br>Ph.D. (Mathematics) | **Course Title:**<br><br>**Numerical Methods in Computational Finance** | | | **Course Code:**<br><br>MTH-6XXX |
|---|---|---|---|---|
| **Type of Course:**<br><br>Program Core | **Prerequisites:**<br><br>A basic knowledge of probability theory, stochastic processes and mathematical finance will be helpful. | | | **Total Contact Hours:**<br><br>45L+30P |
| **Year/Semester:** | **Lecture (L)**<br>**Hrs/Week:**<br><br>3 | **Tutorial (T)**<br>**Hrs/Week:** | **Practical(P)**<br>**Hrs/Week:**<br><br>2 | **Credits:**<br><br>4 |

**Learning Objective:**

This is an introductory course on numerical methods for financial option pricing model. The aim of this course is to enable the student to solve numerically model problems from financial mathematics, especially option pricing. Various efficient computational methods based on a sound mathematical analysis are included in this course to solve different classes of option pricing problems. This course is designed to enable students to evaluate and select among the methodologies, tools and general skills of the subject area. At the end of the course, students are able to initiate independently or carry out collaborative research work in this area. It it is the explicit focus of the course to analyse practical and theoretical problems with the help of numerical simulation based on a suitable mathematical financial model.

**Course outcomes (COs):**

| **On completion of this course, the students will have the ability to:** | | **Bloom's Level** |
|---|---|---|
| **CO-1** | Understanding with the basics of the option pricing problems | |
| **CO-2** | Solve the resulting problem classes efficiently by computational methods based on a sound mathematical analysis | |
| **Co-3** | Analyse and simulate stochastic differential equations using appropriate, advanced | |

| | | |
|---|---|---|
| | methods | |
| **CO-4** | Pursue further research in the allied areas | |

| Course Topics | Lecture Hours | |
|---|---|---|
| **UNIT – I**<br><br>**Topics: Option Pricing via Transform Techniques, Fourier and Integration Method** | | **10** |
| **1.1)** Derivative pricing via the Fast Fourier Transform, Fractional Fast Fourier Transform, Derivative pricing via the Fourier cosine (COS) method. Cosine method for path dependent option | 5 | |
| **1.2)** A primer on characteristic function, Pricing using characteristic function, Pricing via saddle point approximation, Numerical integration and quadrature method | 5 | |
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| **UNIT – II**<br><br>**Topics: Introduction to Finite Differences, Option pricing via Numerical solution of PDE's, Option pricing via Numerical solution of PIDE's** | | 25 |
| **2.1)** Reduction of Black Scholes PDEs to the heat equation, Direct solution to the heat equation, Separation of variables and Strum-Liouville problems, Taylor's expansion, Finite difference method, Expicit, Implicit schemes, Generalized θ-scheme, Exponentially fitted schemes, Multi step schemes, Stability and convergence analysis, Derivative approximation by Finite differences: Generic approach Matrix equation solver. | 12 | |
| **2.2)** Option pricing under the generalized Black-Scholes PDE's, Boundary conditions and critical points. Non uniform grid points, Dimension reduction, Pricing path-dependent option in diffusion framework, finite difference approximation of higher dimensional problems. | 8 | |
| **2.3)** Numerical solution of PIDE's, Simulation methods for derivative pricing, Random number generation samples from various distributions, Models of dependence, Brownian bridge | 5 | |
| | | |
| **UNIT – III** | | **10** |

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|---|---|---|
| **Topics: Monte-Carlo Simulation** | | |
| **3.1)** High dimensional valuation problem, Numerical integration of stochastic differential equation,SimuIating SDE's under different model, Variance reduction techniques, Path-dependent problem, Quasi-Monte Carlo method | 10 | |
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**Textbook References:**
**Text Book:**

1. Computational Methods in Finance by Ali Hirsa, Chapman and Hall, CRC Financial Mathematics Series
2. Numerical methods in Finance and Econometrics by Paolo Brandimarte, John Wiley & Sons.

**Reference Book:**

3. Numerical Methods in Computational Finance by Daniel J. Duffy, Wiley.
4. An Algorithmic Introduction to Numerical Simulation of Stochastic Differential Equations by Desmond J. Higham - SIAM Review, Vol.43, No.3, pp.525–546 (2001).

5. Mathematical Modeling and Computation in Finance by CW Oosterlee and LA Grzelak – World Scientific (2020)

**Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):**

https://www.ma.imperial.ac.uk/~ajacquie/IC_Num_Methods/IC_Num_Methods_Docs/NMImperial.pdf

| **Evaluation Method** | |
|---|---|
| **Items** | **Weightage (%)** |
| Presentation | 40 |
| Midterm | 20 |
| End-Term | 40 |

**CO and PO Correlation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | |
| **CO2** | | | | | | | |
| **CO3** | | | | | | | |
| **CO4** | | | | | | | |

S- Strong; M-Medium; L-Low

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**Last Updated On: Aug 2023**

**Updated By: Vikas Gupta**
**Approved By:**