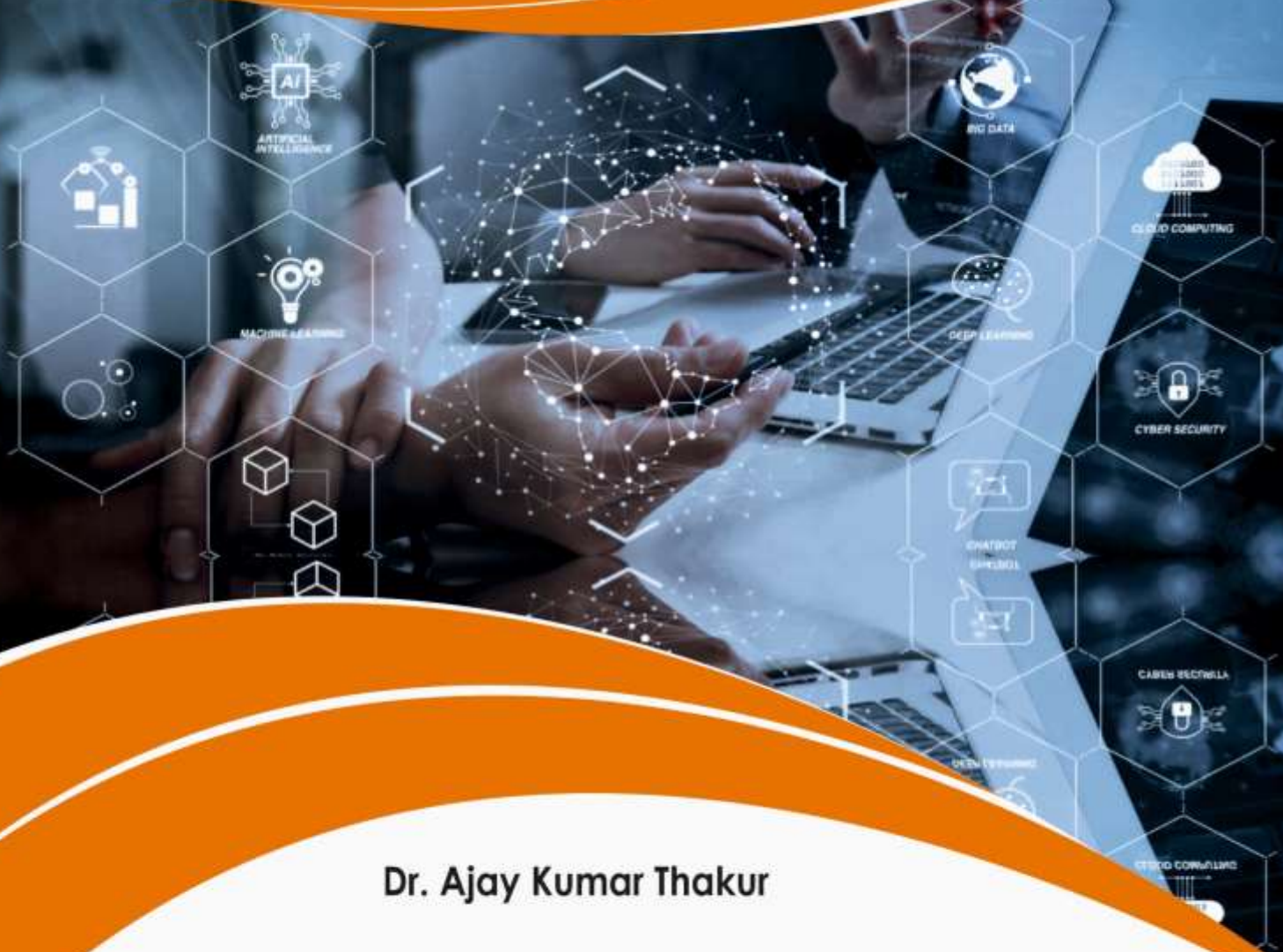


CONCEPT OF SIMULATION AND MODELLING

For M.Sc. II SEM
(All Universities of Bihar)



Dr. Ajay Kumar Thakur

Kripa Drishti Publications, Pune.

CONCEPT OF SIMULATION AND MODELLING

For M.Sc. II SEM
(All Universities of Bihar)

Dr. Ajay Kumar Thakur

Department of Physics,
C. M. Science College,
Darbhanga, Bihar.

Kripa-Drishti Publications, Pune.

Book Title: **Concept of Simulation and Modelling**

Author By: **Dr. Ajay Kumar Thakur**

Price: ₹599

1st Edition

ISBN: **978-81-19149-11-7**



Published: **April 2023**

Publisher:



Kripa-Drishti Publications

A/ 503, Poorva Height, SNO 148/1A/1/1A,

Sus Road, Pashan- 411021, Pune, Maharashtra, India.

Mob: +91-8007068686

Email: editor@kdpublishations.in

Web: <https://www.kdpublishations.in>

© **Copyright Dr. Ajay Kumar Thakur**

All Rights Reserved. No part of this publication can be stored in any retrieval system or reproduced in any form or by any means without the prior written permission of the publisher. Any person who does any unauthorized act in relation to this publication may be liable to criminal prosecution and civil claims for damages. [The responsibility for the facts stated, conclusions reached, etc., is entirely that of the author. The publisher is not responsible for them, whatsoever.]

PREFACE

This book **Concept of Simulation and Modelling**, as well as the associated software and models, were created as a teaching tool. Professional practitioners can use the book to clarify and review key practical concepts in performance modelling with simulation, as well as some advanced programming in OOSimL and Java. The book does not present the detailed statistical treatment theory found in standard system simulation textbooks. It is not a comprehensive reference on system performance measures. The book only includes the basic probability theory required to understand how to apply the appropriate probability distribution in the construction of simulation models. The book also includes basic material that briefly presents the concepts and techniques of verification and validation of simulation models. The book also includes basic material that briefly introduces the concepts and techniques of simulation model verification and validation. Most other books on traditional discrete-event simulation cover simulation theory, statistical analysis, validation, and performance issues in greater depth. This book is intended for college students majoring in computer science, mathematics, science, engineering, or management science. The book's content can also be used as a textbook for an applied course in object-oriented programming. This book is better suited as a supplement to courses in advanced performance modelling and analysis. The following are the book's main features:

Another goal of the book is to provide programmers with a smooth transition from object-oriented modelling to object-oriented simulation. One or more complete case studies are presented and explained for each topic discussed, with the corresponding case study implemented in the OOSimL (and Java) programming languages.

Abbreviations

- Graphical Processing Units (GPUs)
- High-Performance Computing (HPC)
- Industrial Organisation (IO)
- Millennium Development Goals (MDGs)
- Molecular Dynamics (MD)
- Monte Carlo (MC)
- Object Oriented Programming (OOP)
- Standard Template Library (STL)
- The Central Limit Theorem (CLT)

INDEX

Unit 1: Object Oriented Programming	1
1.1 Software Crisis:.....	1
1.2 Software Evaluation:	1
1.3 Procedure-Oriented Programming:	2
1.4 Object Oriented Paradigm:	3
1.5 Basic Concepts of Object-Oriented Programming:.....	4
1.5.1 Objects:	4
1.5.2 Classes:.....	5
1.5.3 Data Abstraction and Encapsulation:	6
1.5.4 Inheritance:	8
1.5.5 Polymorphism:.....	9
1.5.6 Dynamic Binding:.....	10
1.5.7 Message Passing:	11
1.6 Benefits of OOP:.....	11
1.7 Object Oriented Language:.....	12
1.8 Application of OOP:.....	13
1.9 Introduction of C++:.....	13
1.9.1 Application of C++:	14
1.10 Simple C++ Program:.....	15
1.10.1 Program Feature:.....	15
1.10.2 Comments:.....	15
1.10.3 Output Operator:	16
1.10.4 The Iostream File:	16
1.10.5 Namespace:.....	16
1.10.6 Return Type of Main ():	17
1.11 More C++ Statements:.....	17
1.11.1 Variables:.....	18
1.11.2 Input Operator;.....	18
1.11.3 Cascading of I/O Operators:	18
1.12 An Example with Class:	19
1.13 Structure of C++ Program:	20
1.14 Creating the Source File:	21
1.15 Compiling and Linking:.....	21
1.16 Summary:.....	22
1.17 Keywords:.....	23
Unit 2: Programming with Python	24
2.1 Introduction.....	24
2.2 Learning About Python:	24
2.3 The Origins of Python:	26
2.4 Python Use:.....	26
2.5 The Benefits and Negatives of Python:	27

2.5.1 The Benefits of Python:	27
2.5.2 The Negatives of Python:.....	29
2.6 Common Terms You Should Know with Python:	30
2.7 Program Development:	31
2.8 Variables:.....	32
2.8.1 Assigning values to your variables:	32
2.8.2 Multiple Assignments:.....	33
2.9 Expression and Statements:	33
2.10 Recursion:.....	34
2.11 Iteration:	35
2.12 Standard Data Types:	36
2.12.1 Strings:.....	37
2.12.2 Lists:	37
2.12.3 Tuples:.....	38
2.12.4 Dictionary:.....	38
2.13 Types of Errors:	39
2.13.1 Syntax Errors:.....	39
2.13.2 Semantic Errors:	43
2.13.3 Execution-Time Errors:.....	45
2.13.4 Data Errors:	51
2.14 Debugging:	53
2.14.1 Debugging Important:.....	53
2.14.1 Some Common Debugging Techniques:.....	54
2.14.3 Debugging Tools:	54
2.14.4 Pdb Tutorials:	54
2.14.5 Python-Specific Debugging Tutorials:.....	55
2.14.6 General Debugging Resources	55
2.15 Functions:	55
2.16 Libraries:	58
2.17 NumPy:.....	60
2.17.1 NumPy Fast:.....	60
2.17.2 NumPy Basics:	60
2.18 SciPy:	64
2.18.1 SciPy Basics:	64
2.19 Matplotlib:	65
2.19.1 Matplotlib Basics:.....	65
2.20 Use of Scilab and R for Scientific Programming:.....	66
2.20.1 Scilab:	66
2.20.2 Typical Usage:.....	68
2.21 Conclusion:.....	68

Unit 3: Ordinary Differtioal Equation and Partial Differential Equation 69

3.1 Ordinary Differtioal Equation:.....	69
3.2 The Runge–Kutta Method:	69
3.3 Explicit Runge–Kutta Methods:	70
3.4 Examples; The RK4 Method Falls in this Framework. Its Tableau is:	72
3.5 Second-Order Methods with Two Stages:.....	72
3.6 Use:	73
3.7 Adaptive Runge–Kutta Methods:.....	74

3.8 Nonconfluent Runge–Kutta Methods:.....	75
3.9 Runge–Kutta-Nyström Methods:.....	75
3.10 Implicit Runge–Kutta Methods:.....	75
3.11 Examples:.....	76
3.12 Stability:.....	77
3.13 Derivation of The Runge–Kutta Fourth-Order Method:.....	78
3.14 Leapfrog Method:.....	80
3.15 Introduction:.....	80
3.16 Industrial Organization:.....	80
3.17 International Competition:.....	80
3.18 Leapfrogging in Developing Countries:.....	81
3.19 Tunneling Through:.....	81
3.21 Examples:.....	82
3.22 Necessary Condition:.....	82
3.23 Leap Frog Method:.....	82
3.24 Recap. of Discretization Methods:.....	83
3.25 The Finite Difference Method:.....	83
3.26 The Leapfrog Method:.....	84
3.27 Inter-dependency of Points:.....	86
3.28 Grid Splitting:.....	86
3.29 Application to Electron Motion in Electric and Magnetic Fields:.....	87
3.30 Lorentz Force:.....	87
3.31 The Motion of a Charged Particle in The Electric and Magnetic Field:.....	88
3.32 Applications:.....	89
3.33 Partial Differential Equation:.....	90
3.34 Partial Differential Equation Definition:.....	90
3.35 How to Represent Partial Differential Equation?.....	90
3.36 Partial Differential Equation Types:.....	91
3.37 Partial Differential Equation Classification:.....	92
3.38 Classification of Second Order Partial Differential Equation:.....	92
3.39 Elliptic Differential Equation:.....	93
3.40 Parabolic Differential Equations:.....	101
3.41 Hyperbolic Differential Equations:.....	104
3.42 Solution of Wave Equation: (Method of Separation of Variables).....	105
3.43 Diffusion Equation for Lagrangian Fluids:.....	108
Unit 4: Matrix Problems.....	111
4.1 Introduction:.....	111
4.2 Matrix:.....	111
4.3 Definition:.....	112
4.4 Order of a Matrix:.....	112
4.5 Types of Matrices:.....	114
4.5.1 Column Matrix:.....	115
4.5.2 Row Matrix:.....	115
4.5.3 Square Matrix:.....	115
4.5.4 Diagonal Matrix:.....	115
4.5.5 Scalar Matrix:.....	115
4.5.6 Identity Matrix:.....	116
4.5.7 Zero Matrix:.....	116

4.6 Equality of Matrices:.....	116
4.6.1 Definition:.....	116
4.7 Jacobi Method:.....	117
4.7.1 Jacobian Method Formula:.....	117
4.7.2 Properties of Jacobian Method:.....	119
4.7.3 Jacobian Method Example:.....	119
4.8 Inverse Matrices:.....	120
4.8.1 Definition:.....	120
4.8.2 The Inverse of a Product AB:.....	121
4.8.3 The Linear Eigenvalue Problem:.....	123
4.9 Basic Properties:.....	123
4.10 Eigenvalues and Eigenvectors Technique:.....	124
4.10.1 Straight-Line Solutions:.....	125
4.10.2 Theorem: Straight-Line Solutions:.....	128
4.10.3 Computation of Eigenvalues:.....	128
4.10.4 Computation of Eigenvalues:.....	129
Unit 5: Monte Carlo Method and Simulation	131
5.1 Introduction:.....	131
5.2 Random Number Generation:.....	132
5.2.1 Multiple Recursive Generators:.....	133
5.2.2 Modulo 2 Linear Generators:.....	134
5.3 Monte Carlo Integration:.....	137
5.3.1 Example:.....	138
5.4 More on Monte Carlo Integration:.....	139
5.4.1 Variance Reduction:.....	139
5.4.2 Stratified Sampling:.....	139
5.4.3 Importance Sampling:.....	140
5.4.4 Control Variates:.....	140
5.4.5 Antithetic Variates:.....	141
5.5 Metropolis- Hastings Algorithm:.....	142
5.1.1 EXAMPLE1. Independence Sampler:.....	143
5.1.2 EXAMPLE2. Uniform Sampling:.....	144
5.1.3 EXAMPLE3. Random Walk Sampler:.....	144
5.6 Ising and Potts Models:.....	146
5.6.1 Ising Model:.....	146
5.6.2 Potts Model:.....	148
5.7 Molecular Dynamic:.....	149
6. References	152



Kripa-Drishti Publications
A-503 Poorva Heights, Pashan-Sus Road, Near Sai Chowk,
Pune - 411021, Maharashtra, India.
Mob: +91 8007068686
Email: editor@kdpublications.in
Web: <https://www.kdpublications.in>

Price: ₹ 599

ISBN: 978-81-19149-11-7

