Tribhuvan University

Institute of Science and Technology

SCHOOL OF MATHEMATICAL SCIENCES

Syllabus

Bachelor in Mathematical Sciences (B.Math.Sc.)

(with Major Actuarial Science) - **FOURTH SEMESTER**

Course Structure

Semester	Papers	Credit
Fourth	MSMT 251 Discrete Mathematics	3
	MSST 251 Applied Probability Models	3
	MSST 252 Mathematical Statistics	3
	MSMT 252 Mathematical Modeling	3
	MSCS 251 Data Structure and Algorithm	3
Total		15

Code No.: MSMT 253 *Full Mark*: 75

Paper: **Discrete Mathematics** *Pass Mark*: 30

Nature: Theory + Lab *Credit*: 3

Course Description:

This is a gentle introduction to the fundamentals of Discrete Mathematics. It deals with mathematical structures that are discrete in nature rather than continuous. Its core area is combinatorics. It covers the key combinatorial topics of combinatorial enumeration and is useful and accessible not only for pure mathematics students, but also for those inclined towards computer science, statistics or applied fields. It has many real-world applications that can be explained using only a few simple definitions. Sets, function, relation, logic, elementary number theory, counting techniques, Induction and recursion, lattices, partially ordered sets are key topics treated in a way that will facilitate the students in being able to think logically and mathematically, and finally making them capable of applying the techniques of discrete mathematics in solving problems.

Learning Objectives:

After successful completion of this course the student will be able to

- Apply the techniques of logic in order to understand and create mathematical proofs.
- Apply the principles of mathematical induction in proofs.
- Apply the concepts of set theory to problems that involve set operations, cardinality and counting techniques.
- Work with order relation and equivalence relation.
- Apply the concepts of relations and functions to problems involving recursion, sequences and set equivalence.

Mode of Delivery:

The course will be taught by lecture (48 hrs), and problem solving and class discussion (24 hrs). Students will be encouraged to utilize the computer whenever possible and wherever applicable.

Unit 1 Foundations **11 hrs**

Prepositional Logic, Prepositional Equivalences , Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Proofs, Proof Methods and Strategy

Sets, Set Operations, Relations and Their Properties, Representing Relations, Functions, Sequences and Summations,

Unit 2 Number Theory **8 hrs**

The Integers and Division, Primes and Greatest Common Divisors, Partial Orderings, Integers and Algorithms, Applications of Number Theory

Unit 3 Induction and Recursion **8 hrs**

Mathematical Induction, Strong Induction and Well-Ordering, Recursive Definitions and Structural Induction, Recurrence Relations

Unit 4 Counting **11 hrs**

Basics of Counting, Pigeonhole Principle, Permutations and Combinations, Binomial Coefficients and Identities, Equivalence Relations, Generalized Permutations and Combinations, Generating Functions, Inclusion-Exclusion, Applications of Inclusion-Exclusion

Unit 5 Graph Theory **10 hrs**

Graphs and Graph Models, Graph Terminology and Special Types of Graphs, Representing Graphs and Graph Isomorphism, Connectivity, Introduction to Trees, Applications of Trees, Spanning Trees, Minimum Spanning Trees

Text Book

Discrete Mathematics and its Applications (*6th edition*), Kenneth H. Rosen, Tata McGraw Hill, Bombay, India

Reference Books

1. *Discrete Mathematics with Applications* Susanna S. Epp, Brooks/Cole 2011,
2. *Discrete Mathematics an Introduction to Proofs and Combinatorics*, Kevin Ferland, Houghton Mifflin Company, 2009
3. *Combinatorics: Topics, Techniques, Algorithms*. Peter J. Cameron. CUP, 1995.
4. *Graphs, networks, and algorithms.* Dieter Jungnickel, Springer, 2005.
5. *A First Course in Discrete Mathematics*. Ian Anderson. Springer, 2001.
6. *An Introduction to Enumeration*. Alan Camina and Barry Lewis Springer, ,2011.

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Code No.: MSST 251 *Full Mark*: 75

Paper: **Applied Probability Models** *Pass Mark*: 30

Nature: Theory *Credit*: 3

Course Description:

The main objective of the course is to teach students on sampling distribution, estimation, testing of hypothesis and statistical tests.

Learning Objectives:

The main objective of the course is to teach students on sampling distribution, estimation, testing of hypothesis and statistical tests.

Mode of Delivery:

The course will be taught by lecture (48 hrs), and problem solving and class discussion (24 hrs). The use of spreadsheet software for problem solving will be encouraged.

***Contents*:**

Unit 1 Sampling Distributions 10 hrs

Definition of a random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of the sample mean, proportion and sample variance (SRS with/ without replacement), standard errors of sample mean and proportion, independence of sample mean and sample variance, estimation of sample size. Exact sampling distributions: Definitions of central χ^2, t and F random variables, probability distributions of central χ^2, t and F and their properties, inter-relations between the distributions, applications of χ^2, t and F distribution in statistics.

Unit 2 Estimation, Estimators and Confidence Intervals 10 hrs

Point estimation: Estimation of parameters, characteristics and properties of a "Good" estimator: unbiasedness, consistency, efficiency and sufficiency and completeness; likelihood function and its properties, Methods of estimation: Maximum likelihood estimation of parameters of binomial, Poisson and normal distribution, properties of maximum likelihood estimator, methods of moments.

Interval estimation: Confidence interval and confidence limits, method for obtaining confidence limits, confidence intervals of mean, variance and difference between means from normally distributed population, confidence interval for proportion, large sample confidence intervals.

Unit 3 Testing of Hypothesis 8 hrs

Testing of hypothesis: Statistical hypothesis, simple and composite hypotheses, test of statistical hypothesis: null and alternative hypotheses, type I and type II errors, level of significance, critical region, power of the test, one tailed and two tailed tests, p-value in testing of hypothesis, likelihood ratio test and its properties.

Unit 4 Statistical tests **10 hrs**

One sample tests for mean of normal population (for known and unknown variance), test for proportion, test for difference between two means and two proportions, paired sample t-test, two independent sample tests for variances of normal populations, relationship between hypothesis testing and confidence interval, one way and two way ANOVA, tests of significance of simple correlation and regression coefficients, Chi-squared tests for independence of attributes and goodness of fit.

Unit 5 Bivariate distributions **10 hrs**

Notion of bivariate random variable, bivariate distributions (discrete and continuous variables): Joint, marginal and conditional distributions, independence of random variables; Transformations of random variables: Jacobian of transformations, distributions of sum, product and ratio of random variables.

Reference Books:

1 Shrestha, H.B., *Statistical Inference*, Ekta Books

2 Rohatgi, V. K. (1984) *Statistical Inference*, Wiley, New York.

3 Hogg R.V and Criag, A.T (1978). *Introduction to mathematical statistics, 4th edition*, MacMillan Publishing Co., Inc., USA.

4 Kanji, G. K. (1999). 100 Statistical Tests, SAGE Publications Ltd., India.

5 Hogg, R. V., Tanis, E. A. & Rao, J. M. (2000) *Probability and Statistical Inference, 7th Edition*, Pearson Education Inc., India.

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Code No.: MSST 252 *Full Mark*: 75
Paper: **Mathematical Statistics** *Pass Mark*: 30
Nature: Theory *Credit*: 3

Course Description:

The course covers stochastic processes and Markov Chains, Markov Processes, survival models and renewal theory.

Learning Objectives: On successful completion of the course the student will be able to:

- Describe and classify stochastic processes.
- Define and apply a Markov chain.
- Define and apply a Markov process.
- Explain concept of survival models.
- Describe estimation procedures for lifetime distributions.
- Derive maximum likelihood estimators for transition intensities..
- Estimate transition intensities dependent on age (exact or census).
- Graduation and graduation tests
- Describe the process of graduation
- State reasons for graduation
- Conduct graduation tests
- Know mortality projections models
- Explain and apply elementary principles of machine learning

Mode of Delivery:

The course will be taught by lecture (48 hrs), and problem solving and class discussion (24 hrs). The use of spreadsheet software for problem solving will be encouraged.

Contents:

UNIT 1 Stochastic Processes and Markov Chain 10hrs

Stochastic processes and it's classification, Markov chain, Chapman- Kolmogorov equations that represent a Markov chain, Stationary distribution for a Markov chain , System of frequency based experience rating in terms of a Markov chain, Time-inhomogeneous Markov chain model and it's applications, Markov chains as a tool for modeling.

UNIT 2 Markov Processes 10hrs

Markov process, Features of a Markov process model, Poisson process, Kolmogorov equations for a Markov process, Survival models, sickness models and marriage models in terms of Markov processes, Other simple applications of a Markov process.

UNIT 3 Survival Models **12hrs**

Survival models, Model of lifetime or failure time from age *x* as a random variable, Gompertz and Makeham laws of mortality, Expected value and variance of the complete and curtate future lifetimes, Estimation procedures for lifetime distributions, **V**arious ways in which lifetime data might be censored, Kaplan-Meier (or product limit) estimator of the survival function in the presence of censoring, Nelson-Aalen estimator of the cumulative hazard rate in the presence of censoring, Models for proportional hazards, Cox model for proportional hazards.

UNIT 4 Survival Models (Contd.) **10hrs**

Derive maximum likelihood estimators for transition intensities, Estimation of transition intensities dependent on age (exact or census), Graduation and graduation tests, Mortality projection, Elementary principles of machine learning and their application.

UNIT 5 Renewal Theory **6 hrs**

Renewal function, Integral equation of renewal theory, Stopping time and Wald's equation, Spent and residual time distribution, Elementary renewal theorem.

Reference Books:

1. Bhat, B. R. (2000), Stochastic Models- Analysis and Applications, New Age International Publishers.
2. Feller, William (1968), An Introduction to Probability Theory and its Applications, Vol. 1 (Third Edition.), John Wiley.
3. Ross, Sheldon M. (1983), Stochastic Processes, 2nd Edition, John Wiley and Sons, Inc.
4. Shrestha, H.B. (2009). Stochastic Processes, An Introductory Text, Ekta Books

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Code No.: MSMT 252 *Full Mark*: 75
Paper: **Mathematical Modeling** *Pass Mark*: 30
Nature: Theory *Credit*: 3

Course Description:
In this course, students will learn how to formulate and analyze mathematical models. The mathematical tools to be handled include dimensional analysis, optimization, numerical simulation, elementary probability and stochastic processes, as well as elementary differential equations. The fields of application include biology, economics, and other areas of science. The necessary mathematical and scientific background will be developed as needed. Students will learn how to simulate models using MATLAB.

Learning Objectives:
Students will learn how to formulate, analyze and simulate mathematical models.

Mode of Delivery:
The course will be taught by lecture (48 hrs), and problem solving and class discussion (24 hrs). Students will be encouraged to utilize the computer whenever possible and wherever applicable.

***Contents*:**

Unit 1 Modeling Change **10 hrs**
Introduction, Mathematical models, Modeling change with difference equations, Approximating change with difference equations, Solution to dynamical systems, Systems of difference equations.

Unit 2 The Modeling Process, Proportionality and Geometric Similarity **10 hrs**
Mathematical models, Modeling using proportionality, Modeling using geometric similarity, Automobile gasoline mileage, Body weight and height, Strength and agility.

Unit 3 Model Fitting **8 hrs**
Fitting model to data graphically, Analytical methods of data fitting, Applying the least squares criterion, Choosing a best model.

Unit 4 Optimization of Discrete Models **10 hrs**
Continuous optimization modeling, Optimization with linear programming, An overview of optimization modeling, Maximizing profit in furniture business, Linear Programming: geometric, Algebraic, Simplex method.

Unit 5 Exponential Growth and Decay **10 hrs**
Calculating and displaying exponential functions, The first order differential equation, Radio active decay, Charging and discharging a capacitor, Exponential models in money matters, A non linear model of population growth, A coupled model of fighting armies,

/Reference books

1. Frank R. Giordano, William P. Fox, Steven B. Horton, Maurice D. Weir, *Mathematical Modeling, Principles and Applications*, Cengage Learning, India Edition.
2. Clive L. Dym, *Principles of Mathematical Modeling*, 2nd Edition, Elsevier.

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Code No.: MSCS 251 *Full Mark*: 75
Paper: **Data Structure and Algorithms** *Pass Mark*: 30
Nature: Theory + Lab *Credit*: 3

Course description:

The aim of this course is to develop concepts of data structures and algorithms. The course helps the students to discover the concepts of data structures, different ADTs, recursion, tree, searching, sorting, graph and different algorithms.

Course objectives:

The main objective of this course is to provide students knowledge of different concepts of data structures, ADTs, and algorithms so that they will be able to implement these concepts in different fileds of computer science.

***Mode of Delivery*:**

The course will be taught by lecture (48 hrs), and lab work (24 hrs). The students are encouraged to develop computer programs related to the concepts of the C language after completion of each chapter.

***Course content*:**

Unit 1 Introduction to Data Structure **2 hrs**

Concept of data structure, Abstract Data Type, Implementation of Data structure

Unit 2 The Stack **4 hrs**

Definition, Stack as an ADT, POP and PUSH operation, Stack application: Evaluation of Infix, Postfix, and Prefix expressions

Unit 3 Queue **3 hrs**

Definition, Queue as an ADT, Primitive operations in queue, Linear and circular queue and their application, Enqueue and Dequeue

Unit 4 List **2 hrs**

Definition, Static and dynamic list structure, Array implementation of lists, Queues as list

Unit 5 Linked Lists **6 hrs**

Definition and link list as an ADT, Dynamic implementation, Basic operations in linked list: node insertion, deletion, insertion and deletion after and before nodes, Linked stacks and Queues, Doubly linked lists and its advantages

Unit 6 Recursion **4 hrs**

Principle of recursion, Comparison between recursion and iteration, Recursion example: TOH and Fibonacci sequence, Applications of recursion, Search tree

Unit 7 Trees **7 hrs**

Concept and definitions, Basic operation in Binary tree, Tree search and insertion/deletions, Binary tree traversals (pre-order, post-order and in-order), Tree height, level, and depth, Balanced trees: AVL balanced trees, Balancing algorithm

Unit 8 Sorting **6 hrs**

Insertion Sort, Selection Sort, Bubble Sort, Merge Sort, and Quick Sort, Efficiency of Sorting, Big 'O' Notation

Unit 9 Searching **6 hrs**

Search technique; essential of search, Sequential search, Binary search, Efficiency comparisons of different search technique

Unit 10 Graphs **8 hrs**

Representation and applications, Graphs as an ADT, Transitive closure, Warshall's algorithm, Graphs types, Graph traversal and Spanning forests, Kruskal's and Round-Robin algorithms, Shortest-path algorithm, Greedy algorithm, Dijkstra's Algorithm

Laboratory Work:

After completing this course, students should be able to implement all the concepts of data structures and algorithms in the syllabus using C/C++ programming language.

Reference Books:

1. Y. Langsam, M.J. Augenstein and A. M. Tenenbaum, Data Structures using C and C++ 2nd Edition
2. G. W. Rowe, Introduction to Data Structure and Algorithms with C and C++
3. Rajesh K. Shukla, Data Structures using C & C++

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