Tribhuvan University

Institute of Science and Technology

Bachelor in Data Science (BDS)
Curriculum 2024

SCHOOL OF MATHEMATICAL SCIENCES

1. Introduction

Data Science is a field that is growing significantly across all industries that advancing with time and technology. Data science program has become a fundamental discipline in most of the universities as applied research in Statistics and Computer Science. Data Science experts are needed in most government agencies. Businesses depend on big data to better serve their customers. Data Science careers are in high demand and this trend will grow exponentially.

Data Science program is a multi-disciplinary subject that includes the use of **Mathematics, Statistics, and Computer Science** and **Information Technology** to study and evaluate data. The key objective of Data Science is to extract valuable information for use in strategic decision making, product development, trend analysis, and forecasting.

The BDS curriculum is designed to provide the breadth and depth of knowledge needed for a successful career in data science. It emphasizes practical proficiency in applying the relevant skills through courses in statistical modelling, data management, artificial intelligence, machine learning, data visualization, and other related areas to uncover actionable insights hidden in an organization's data. The accelerating volume of data sources, and subsequently data, has made data science is one of the fastest growing field across every industry.

2. Objectives

Upon completion of this program, students will be able to:

- Create data science enabled solutions to different data science related real-world problems applicable to the needs of different sectors.
- Collect, clean, and organize large amounts of data for data analysis.
- Create knowledge and skills in both computer science, statistical modelling, and mathematics for data intensive problem solving.
- Engage in continuous learning understanding ethical, professional, and social issues related to data science.

3. Duration and Nature of the Course

Bachelors in Data Science a full-time program having eight Semesters in four years duration. This program basically comprises of some foundational courses consisting of fundamentals of Mathematics, Statistics, and Computer Science and Technology including algorithms, artificial intelligence, machine learning, computer and statistical programming, data analysis,

database systems, and web development and other data science related subjects. Each course with 3 credit hours except seminar, project work, and internship will be taught 48 hours in each semester.

Total credit hours: 123 Credit hours

Nature of courses: Theoretical, Practical, Project, Seminar, Internship

4. Eligibility Criteria

The candidate applying for admission to the BDS program must have completed 10 + 2 or equivalent examinations in any stream with minimum second division (securing 45% and above) or minimum 'C' grade in all subjects of grade 11 and 12.

5. Evaluation

All the courses except seminar, project work and internship should have internal weightage of 40% and external weightage of 60%. A student should secure minimum of 40% in each category to pass a course. Final examination will be conducted at the end of each semester for each course except seminar, project work and internship. The weightage of this final examination is 60% of the overall weightage. The final grade and grade point in each course will be the sum of overall weightage of in all categories.

For the courses having laboratory work, 50% of the overall internal weightage is assigned for practical examination. The school may invite a subject expert for the evaluation of practical examination.

Seminar, project work and internship are evaluated by different evaluators. To pass these courses, students should secure at least 40% marks in the evaluation of each evaluator and the final grade and grade point will be the sum of all the evaluations. For the evaluation of final presentation, an external examiner will be assigned.

6. Grading System

The grade awarded to each student in each course is based on his/her overall performance through internal and external evaluations. Several evaluation criteria are used for the continuous internal evaluation. External evaluation is solely based on final examination conducted by the University. The grade in each course is assigned using a letter grade that indicates the overall performance of each student in each course. The chart below represents letters with its corresponding grading scale, grade point, and performance remarks.

Letter Grade	Grading Scale	Grade Point	Performance Remarks
A	90 – 100	4	Outstanding
A-	80 – less than 90	3.7	Excellent
B+	70 – less than 80	3.3	Very Good
B	60 – less than 70	3	Good
B-	50 – less than 60	2.7	Satisfactory
C	40 – less than 50	2.3	Pass*
F	0 – less than 40	0	Fail

*Pass refers to acceptable

The performance of each student in each semester shall be evaluated in terms of Semester Grade Point Average (SGPA) which is the grade point average for the semester. SGPA is calculated as

$$SGPA = \frac{Total\ Grade\ Points\ earned\ in\ a\ semester}{Total\ number\ of\ credits\ earned\ in\ the\ semester}$$

The cumulative grade point average (CGPA) is the grade point average for all completed semesters. CGPA is calculated as

$$CGPA = \frac{Total\ Grade\ Points\ earned}{Total\ number\ of\ credits\ completed}$$

7. Teaching Pedagogy

The general teaching pedagogy of BDS includes class lectures, group discussions, case studies, guest lectures, research work, project work (individual and group), assignments (theoretical and practical), and term papers. The teaching faculty will determine the choice of teaching pedagogy as per the need of the course. The concerned faculty shall develop a detailed course outline and work plan at the beginning of each semester.

8. Course Structure

First Semester		
Course Code	**Course Title**	**Credit Hours**
BDS101	Introduction to Data Science	3
BDS102	Basic Computer Organization	3
BDS103	Programming in C	3
BDS104	Statistics for Data science	3
BDS105	Calculus I	3
Total Credit Hours		**15**

Second Semester		
Course Code	**Course Title**	**Credit Hours**
BDS151	Python Programming	3
BDS152	Database Management System	3
BDS153	Probability Distribution	3
BDS154	Calculus II	3
BDS155	Linear Algebra	3
Total Credit Hours		**15**

Third Semester		
Course Code	**Course Title**	**Credit Hours**
BDS201	Data Structure and Algorithms	3
BDS202	Operating System	3
BDS203	R Programming	3
BDS204	Inferential Statistics	3
BDS205	Differential Equations	3
BDS206	Seminar	1
Total Credit Hours		**16**

Fourth Semester		
Course Code	**Course Title**	**Credit Hours**
BDS251	Artificial Intelligence	3
BDS252	Web Development	3
BDS253	Data Communications and Computer Networking	3
BDS254	Discrete Mathematics	3
BDS255	Technical Writing	3
Total Credit Hours		**15**

Fifth Semester		
Course Code	**Course Title**	**Credit Hours**
BDS301	Machine Learning	3
BDS302	Software Design and Development	3
BDS303	Data Visualization	3
BDS304	Numerical Methods	3
BDS305	Economics	3
BDS306	Project I	2
Total Credit Hours		**17**

Sixth Semester		
Course Code	**Course Title**	**Credit Hours**
BDS351	Data Warehousing and Data Mining	3
BDS352	Artificial Neural Network	3
BDS353	Computer Graphics and Image Processing	3
BDS354	Research Methodology	3
BDS355	Principles of Management	3
Total Credit Hours		**15**

Seventh Semester		
Course Code	**Course Title**	**Credit Hours**
BDS401	Object Relational and NoSQL Databases	3
BDS402	Simulation and Modeling	3
BDS403	Data Security	3
BDS404	Project II	3
Elective I (Chose any one)		
BDS421	Cloud Computing	3
BDS422	Deep Learning	3
BDS423	Mobile Application Development	3
BDS424	Blockchain Technology	3
BDS425	Exploratory Data Analysis	3
Total Credit Hours		**15**

Eighth Semester		
Course Code	**Course Title**	**Credit Hours**
BDS451	Information Retrieval	3
BDS452	Big Data Analytics with Hadoop	3
BDS453	Natural Language Processing	3
BDS454	Internship	3
Elective II (Chose any one)		
BDS471	Social Network Analysis	3
BDS472	Forecasting Analysis	3
BDS473	Digital Marketing	3
BDS474	Business Intelligence	3
BDS475	Internet of Things	3
Total Credit Hours		**15**

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Course of Study

Program: Bachelor in Data Science
Paper: **Introduction to Data Science**
Nature: Theory
Semester: I

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS101**
Credit Hours: 3

Course Description:

This is an introductory course to teach the basics of data science, it's applications, and commonly used tools and techniques. The course is designed to introduce key ideas and methodologies used in the domain of data science. The goal of this course is to help understand the fundamental building blocks of data science.

Course Objectives:

Upon the conclusion of the course, students should be able to

- Describe Data Science, skill sets needed to be a data scientist and be familiar with common tools used for data science.
- Understand the importance of data quality and familiarize with common data munging techniques
- Understand and apply commonly used data analysis and machine learning techniques in data science
- Identify the challenges in handling big data, and gain a general understanding of ecosystem of big data
- Reason around ethical and privacy issues in data science and understand the common biases affecting data science

Course Contents:

Unit 1 Introduction to Data Science **6 hrs**

Introduction to data science; Data Science Hype; Data, Data Science, Engineering and Data-Driven Decision Making; Statistics and Data Science; Data Science Process; Data Science Profile; Data Analytics vs Data Science; Roles and Responsibilities of Data Scientist; Data Science Lifecycles (OSEMN, CRISP-DM, TDSP); Tools and Technologies; Limitations of data science; Applications of Data Science

Unit 2 Big Data **8 hrs**

Structured, Semi-Structured and Unstructured data; Understanding Database, Data Warehouse and Data Lake; Characteristics of Data warehouse, ETL(Extract-transform-load) Techniques

Introduction to Big Data; Need for Big Data; Challenges of handling big data; Characteristics of big data; Map-Reduce programming paradigm, and its differences from conventional programming models; Solving Word Count Problem through Map Reduce Paradigm; Hadoop and its components; Hadoop Ecosystem

Unit 3 Data Wrangling and Feature Engineering 12 hrs

Commonly used data formats; Collecting and Importing data; Exploratory Data Analysis; Data Quality; Common issues with real world data; Data Cleaning Techniques; Data Enrichment; Data Validation; Data Publishing

Feature Engineering: Introduction to Feature Engineer; Feature Selection; Feature Selection Techniques: Filters, Wrappers and Embedded Methods; Feature Scaling and Standardization; Feature Extraction

Unit 4 Machine Learning 12 hrs

Understanding Predictive analytics and Machine Learning; Artificial Intelligence vs Machine Learning; their practical applications; Machine Learning Techniques: Supervised, Unsupervised, Semi-supervised and Reinforcement learning and their types.

Regression Techniques: Linear Regression, Polynomial Regression; Classification Techniques: Logistic Regression, KNN, Decision Tree, Naïve Bayes; Clustering Techniques: K Means, K Medoids; and their pros and cons.

Model Evaluation: Root Mean Squared Error, Mean Absolute Error, Mean Percentage Error; Confusion Matrix; Accuracy, Precision and Recall

Unit 5 Data Visualization and Story Telling 6 hrs

Introduction to Data Visualization, Exploratory vs Explanatory data visualization; Common Data Visualization Techniques and their usage: Table, Pivot Table, Histogram, Bar Chart, Line Chart, Scatter plot, Pie Chart, Box Plot etc.

Data Story Telling: Introduction, Need for Data Story Telling; Components of Data Storytelling; Benefits of Data Story Telling; Communicating data insights.

Unit 6 Ethical Issues in Data Science 4 hrs

Ethics for Data Scientist; Case Study of Facebook and Cambridge Analytica; Common issues with privacy and data ethics

Introduction of biasness and fairness; Issues with fairness and bias in data science; Common Cognitive biases: Anchoring Bias, Sampling Bias, In group favoritism and out-group negativity, Fundamental attribution error, Negativity bias, Stereotyping, Bandwagon effect, Bias blind spot; Addressing Cognitive biases: Group unaware selection, Adjusted group thresholds, Demographic parity, Equal opportunity, Precision parity

Reference Books:

1. O'Neil, Cathy and Schutt, Rachel (2013), *Doing Data Science***,** *Straight Talk From TheFrontline*, O'Reilly Media
2. Skiena, Steven (2017), *The Data Science Design Manual*, Springer
3. Provost, Foster and Fawcett, Tom (2013). *Data Science for Business***:** *What You Need to Know about Data Mining and Data-analytic Thinking*, O'Reilly Media

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Course of Study

Program: Bachelor in Data Science
Paper: **Basic Computer Organization**
Nature: Theory + Practical
Semester: I

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS102**
Credit Hours: 3

Course Description:

This course covers fundamental principles of computer systems, instructions sets and its design, hierarchy of computer organization, from the digital logic level to the operating system level. It focuses on a modular approach to understanding computer systems and clarifies complex concepts through a systematic presentation.

Course Objectives:

The main objective of this course is to provide comprehensive understanding of how computer systems are structured and function.

Course Contents:

Unit 1 Introduction **8 hrs**

Structured Computer Organization: Languages, Levels, and Virtual Machines; Contemporary Multilevel Machines; Evolution of Multilevel Machines; Milestones in Computer Architecture: Different Generation of Computers; The Computer Zoo: Different Technologies and Different Types of Computers

Unit 2 Computer Systems **10 hrs**

Processors: CPU Organization, Instruction Execution, RISC versus CISC, Design Principles for Modern Computers, Instruction-Level Parallelism, Processor-Level Parallelism; Primary Memory: Bits, Memory Addresses, Byte Ordering, Error-Correcting Codes, Cache Memory, Memory Packaging and Types; Secondary Memory: Memory Hierarchies, Magnetic Disks, IDE Disks, SCSI Disks, RAID, Solid-State Disks, CD-ROMs; Input/Output: Buses, Terminals, Mice, Game Controllers, Printers

Unit 3 Digital Logic Level **12 hrs**

Gates and Boolean Algebra: Gates, Boolean Algebra, Implementation of Boolean Functions, Circuit Equivalence; Basic Digital Logic Circuits: Integrated Circuits, Combinational Circuits, Arithmetic Circuits, Clocks; Memory: Latches, Flip-Flops, Registers, Memory Organization, Memory Chips, RAMs and ROMs; CPU Chips and Buses: CPU chips, Computer Buses, Bus Width, Bus Clocking, Bus Arbitration, Bus Operations

Unit 4 The Microarchitecture Level **4 hrs**

The Data Path, Microinstructions and Notation; Introduction to pipelining

Unit 5 The Instruction Set **10 hrs**

Brief Introduction to ISA Level and its properties; Memory Models; Registers; Instructions, Instruction Formats and Design Criteria for Instruction Formats; Different Addressing Modes

Unit 6 The Operating System **4 hrs**

Virtual Memory; Paging; Segmentation

Laboratory Works:

Students should implement different combinational and sequential circuits in a standard simulator. They must be able to realize pipelining and different addressing modes.

Reference Books:

1. Andrew S. Tanenbaum and Todd Austin, "Structured Computer Organization", Pearson Education, Sixth Edition
2. William Stallings, "Computer Organization and Architecture – Designing for Performance", Pearson Education, Ninth Edition,
3. David A. Patterson and John L. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Elsevier, Third Edition

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Course of Study

Program: Bachelor in Data Science
Paper: **Programming in C**
Nature: Theory+ Practical
Semester: I

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS103**
Credit Hours: 3

Course Description:

This course introduces the both theoretical and practical concepts of C programming language including basic concepts, data types, operators, handling input and output, control statements, arrays, functions, pointers, structures, unions, and file handling.

Course Objectives:

The main objective of this course is to familiarize students both theoretical and practical concepts of C programming language.

Course Contents:

Unit 1 Introduction **3 hrs**

Program and programming language, Types of programming languages, Program design tools (Algorithm, Flowchart, and Pseudocode), History of C programming, Structure of C program, Compiling and executing C programs, Debugging

Unit 2 Basic Elements of C **4 hrs**

C standards, C character set, C tokens, Escape sequence, Delimiters, Variables, Data types, Constants/Literals, Symbolic constant, Expressions, Statements, Writing comments, Library functions and Pre-processor directives

Unit 3 Data Input and Output **3 hrs**

Input/output operations, Conversion specifications, Formatted I/O and unformatted I/O

Unit 4 Operators and Expression **5 hrs**

Unary and binary operators, Arithmetic operator, Relational operator, Boolean operator, Assignment operator, Ternary operator, Bitwise operator, Increment or decrement operator, Conditional operator, Special operators (size of operator), Evaluation of expression, Operator precedence and associativity, Type conversion

Unit 5 Control Statements **6 hrs**

Branching statements (if and switch), Looping statements (for, while, and do-while), Nested control structures, Break and continue statements, Exit function

Unit 6 Arrays and Strings **6 hrs**

Introduction to array, Types of array (Single dimensional and multidimensional), Declaration and memory representation of array, Initialization of array, Character array and strings, Reading and writing strings, Null character, String library functions

Unit 7 Functions **6 hrs**

User defined functions, Library functions vs. User defined functions, Function prototype, Function call and Function definition, Nested and recursive function, Function arguments and return types, Passing arrays to function, Passing strings to function, Passing arguments by value, Passing arguments by address, Local and global variable, Scope visibility and lifetime of a variable, Macros

Unit 8 Pointers **6 hrs**

Introduction to pointers, Advantages and disadvantages of pointer, The & and * operator, Declaration of pointer, Pointer to pointers (Chain of Pointers), Pointer arithmetic, Pointers and arrays, Pointers and character strings, Array of pointers, Pointers as function arguments, Function returning pointers, Dynamic memory allocation

Unit 9 Structure and Union **5 hrs**

Introduction, Declaration, Initialization, Array of structure, Passing structure to function, Passing array of structure to function, Nested structure, Pointers and structures, Introduction to union, Structure vs union

Unit 10 File Handling in C **4 hrs**

Concept of file, Types of file (Text and binary files), Modes of file, Opening and closing of file, Input output operations in file, Random access in file

Laboratory Works:

Laboratory work includes writing C programs to implement all the concepts of C programming studied in each unit of the course.

Reference Books:

1. Byron Gottfried: "Programming with C," Fourth Edition, McGraw Hill Education.
2. Brian W. Keringhan, Dennis M. Ritchie, The C programming Language, Second Edition, PHI Publication.
3. Al Kelley, Ira Pohl: "A Book on C", Fourth Edition, Pearson Education.
4. YeshvantKanetkar, "Let Us C", 17 th Edition, BPB publication, 2020.
5. Herbert Schildt, C Complete Reference, Fourth Edition, Osborne/McGraw- Hill Publication.
6. K.N. KING: C Programming: A Modern Approach, Second Edition
7. E. Balagurusamy, Programming in ANSI C, Eigth Edition, TMH publication, 2019

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Course of Study

Program: Bachelor in Data Science
Paper: **Statistics for Data Science**
Nature: Theory+ Practical
Semester: I

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS104**
Credit Hours: 3

Course Description:

This course focuses on fundamental statistical techniques that are of particular relevance to Data Science. The course covers basic statistics with exploratory data analysis, moments, skewness and kurtosis, correlation and regression analysis, probability, index number, time series analysis and forecasting.

Course Objectives:

After successful completion of the course, students will be able to

- Describe the nature of data, summarize and explore data
- Understand and apply descriptive statistical measures relevant to Data Science
- Perform correlational analysis and build linear regression model with model adequacy tests
- Compute index numbers for economic analysis
- Perform time series analysis and develop forecasting models for time series data
- Understand about basic principles and properties of probability, calculate marginal, joint and conditional probabilities using addition, multiplication, and Bayes' rule

Course Contents:

Unit 1 Introduction **2 hrs**

Definition, scope and importance of Statistics; Population and sample data; Variable and its types: discrete and continuous; Qualitative and quantitative Sources of data: primary and secondary; Types of data: cross-sectional, temporal and panel; Scale of measurement of data: nominal, ordinal, interval and ratio; Application of Statistics in Data Science

Unit 2 Data summarization **10 hrs**

Definition and need of data summarization; Methods of data summarization: tabular and graphical methods, frequency tables, cross-tabulations, bar diagrams, pie chart, histogram, frequency curve, ogives, frequency polygon; Measures of central tendency, partition values, dispersion, asymmetry (skewness) and kurtosis and their computational methods; Moments: raw and central moments, relation between raw and central moments, properties of moments; Exploratory data analysis: stem-and-leaf display, five number summary, box-plot;Solving problems relevant to Data Science

Unit 3 Correlation and regression analysis **12 hrs**

Correlation and its types, assumptions, scatterplot, Karl Pearson's correlation coefficient: definition, computation, properties; Spearman's and Kendall's rank correlation coefficients; Simple and multiple linear regressions, assumptions of linear regressions model, lines of regressions, fitting linear regression using ordinary least square method, interpretation of intercept and slope, relation between correlation and regression parameters, goodness of fit, coefficient of determination, residual analysis; Solving problems relevant to Data Science

Unit 4 Index numbers **8 hrs**

Introduction, simple and weighted index numbers, methods of construction of index numbers for price, quantity and value indices using unweighted and weighted aggregate methods: Laspeyers, Paasche, Fisher, fixed-weight aggregate methods, average of relative method; Consumer price index, purchasing power of money, real wages, base shifting, inflation and deflation; Time reversal and factor reversal tests; Issues in constructing and uses of index numbers; Applications of different index number techniques in monetary and finance related data

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Unit 5 Time series analysis and forecasting **10 hrs**

Introduction, components of a time series- secular trend, cyclic variation, seasonal variation, irregular variation; Time series analysis for forecasting using trend projection method, moving average method, curvilinear methods; Seasonal variation, determining the seasonal index, de-seasonalizing data; Test for autocorrelation; Forecasting methods- naive methods, linear methods, moving average methods, and simple exponential smoothing method; Measuring accuracy of forecasting models using mean square error (MSE), mean absolute deviation (MAD) and mean absolute percentage error (MAPE); Solving problems relevant to Data Science

Unit 6 Probability **6 hrs**

Review of fundamental concepts of probability, counting rules, types of probability, laws of probability, conditional probability, pair-wise and mutually independence; Bayes' theorem and its application, prior and posterior probability. Solving problems relevant to Data Science

Laboratory Works:

The laboratory work includes using any statistical software such as Microsoft Excel, SPSS, R etc.

Practical Problems

S. No.	Title of the Practical Problems	No. of practical Problems
1	Mean, median, mode, partition values, measures of dispersion and coefficient of variation.	2
2	Measure of skewness and kurtosis, five number summary and Box and whisker plot.	2
3	Scatter diagram, Karl Pesrso's correlation coefficient and Spearman's Rank correlation coefficient (ungrouped data) and interpretation. Compute manually and check with computer output.	2
4	Fitting of simple regression model, calculation of error term, standard error of the estimate, coefficient of determination and interpretation. Residuals plot	2
5	Fitting of multiple regression model, calculation of residuals, standard error of the estimate, coefficient of determination and interpretation.	2
6	Computation of probability in different conditions and Bayes' theorem.	1
7	Calculation of unweighted and weighted index number.	2
8	Linear and quadratic models, percent of trend, relative cyclical residual and interpretation of results.	1
9	Forecasting models	1

References Books:

1. Bruce Peter and Bruce Andrew (2017). *Practical Statistics for Data Scientists,* O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472, U.S.A.
2. Sheldon M. Ross (2010). *Introductory Statistics*, Elsevier Publication, U.S.A.
3. Neil Weiss (2010): *Introductory Statistics*, 5th edition: Pearson Publishers
4. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying YE, *Probability and Statistics for Engineers and Scientists*, Pearson, 2012.
5. Anderson David R., Williams Thomas A., Cochran James J., Sweeney Dennis, Camm Jeffrey D., Ohlmann Jeffrey W. *Statistics for Business & Economics*, 14th Edition, Cengage Learning Inc., U.S.A.

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Course of Study

Program: Bachelor in Data Science | *Full Marks*: 45+30
Paper: **Calculus I** | Pass Mark: 18+12
Nature: Theory | Course *Code*.: **BDS105**
Semester: I | *Credit Hours*: 3

Course Description:

This course includes limits, continuity, differentiation and integration of algebraic and transcendental functions, and their applications.

Learning Objectives:

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

- Solve the problems of limit, continuity, differentiation and integration
- Apply the techniques of calculus to solve real life problems

Course Contents:

Unit 1 Limits and Continuity **8 hrs**

Limit of a function; Calculating limits using the limit laws; Computing limits of algebraic functions by definition; Limits at infinity; Asymptotes: horizontal, vertical and oblique, Continuity at a point

Unit 2 Derivatives **7 hrs**

Derivatives and their rules; Linear approximations and differentials; Indeterminate forms and L'Hospital's rule; Higher order derivatives

Unit 3 Application of Derivative **10 hrs**

Rolle's Theorem and Mean value theorem; Monotonic functions; Optimization problems; Marginal analysis; Sketching curve using calculus; Newton's method

Unit 4 Integrals **13 hrs**

Definite integral; Fundamental theorems of calculus; Indefinite integrals and their properties; Properties of definite integrals; Reduction formulae; Improper integrals; Beta and Gamma functions; Numerical methods of integration.

Unit 5 Application of Integration **10 hrs**

Areas between curves; Volumes; Volumes by cylindrical shells; Average value of a function; Arc length; Area of a surface of revolution; Applications in economics

Reference Books:

1. Stewart J., Calculus: Early Transcendental Functions, 7th edition, Thomson Brooks/Cole
2. Larson, et al, Calculus: Early Transcendental Functions, Houghton Mifflin, 2011
3. Robert A. Adams, Christopher Essex, Calculus: a complete course, Pearson, 2010

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Course of Study

Program: Bachelor in Data Science
Paper: **Python Programming**
Nature: Theory+ Practical
Semester: II

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS151**
Credit Hours: 3

Course Description:

This course covers different concepts of Python programming including basic language concepts, control statements, functions, comprehensions, generators, decorators, iterators, object-oriented programming concepts, exception handling, file handling, modules and packages, and some common Python libraries.

Course Objectives:

The main objective of this course to provide knowledge to student with different concepts of Python programming language python programming and some common Python libraries such as Numpy, Pandas, and Matplotlib.

Course Contents:

Unit 1 Introduction **3 hrs**

Python introduction; Why Python; Installing Python; Using interactive shell from console; Running Python scripts from console; Using interactive shell from IDLE; Using IDEs; Installing third party libraries; Writing comments; Indentation; Variables; Operators

Unit 2 Built-In Data Types **7 hrs**

Numbers – integers, Booleans, Real numbers, Complex numbers, Fractions and decimals; Immutable sequences – strings, bytes, and tuples; Mutable sequences – lists, bytearrays; Set types; Mapping types – dictionaries; Dates and times; Collections module; Small value cashing; Indexing and slicing.

Unit 3 Conditionals and Iterations **5 hrs**

Introduction; The if statement; The for loop; The while loop; The break and continue statements; The else clause after for or while loops; The walrus operator

Unit 4 Functions **4 hrs**

Introduction; Why use functions? Defining functions; passing arguments; Return values and returning multiple values; Recursive function; Anonymous function; Built-in functions

Unit 5 Comprehensions and Generators **3 hrs**

The map, zip, and filter functions; Comprehensions – list, Dictionary and set comprehensions; Generators

Unit 6 Object-oriented Programming, Decorators, Iterators, and Modules **14 hrs**

Decorators; Object-oriented programming concepts; Creating class and object; Inheritance; Static methods and class methods; Private properties; The property decorator; Operator overloading; Writing custom iterator; Modules and packages.

Unit 7 Exception and File Handling **4 hrs**

Exceptions; Handling exceptions; Defining your own exception; Reading and writing files; Reading and writing CSV files.

Unit 8 Basic Data Processing and Analysis Using Python Libraries 6 hrs

Numpy: Introduction array creating; Dimensions; Data types, Array attributes, Indexing and slicing; Array copy and view; Creating array from numerical range; Array broadcasting; Iterating over array; Sorting and Searching; Statistical Functions

Pandas: Series and data frames; Creating data frames; The head and tail functions; Attributes; Working with missing data; Indexing, slicing, and subsetting; Merging and joining data frames; Working with CSV data.

Unit 9 Data Visualization with Matplotlib 2 hrs

Introduction; Marker; Line; Color; Label; Grid lines; Subplot; Scatter plot; Bra graph; Histogram, pie chart and box plot.

Laboratory Works:

The laboratory work includes writing computer programs using Python programming language covering all the concepts studied in each unit of the course.

References Books:

1. Fabrizio Romano and Heinrich Kruger, *Learn Python Programming – An in-depth Introduction to the Fundamentals of Python,* 3rd Edition, Packt Publishing, 2021
2. Kenneth A Lampart, *Fundamental of Python,* Cengage Learning Publishing.
3. Cody Jackson, *Learn Programming in Python with Cody Jackson*, Packt Publishing, Wesley, 2018
4. Mark Summerfield, *Programming in Python 3: A Complete Introduction to the Python Language*, Addison-Wesley Professional.

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Course of Study

Program: Bachelor in Data Science
Paper **Database Management System**
Nature: Theory+ Practical
Semester: II

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS152**
Credit Hours: 3

Course Description:
A course in database management systems provides an in-depth understanding of how to design, implement, and maintain a database. The course covers the fundamentals of database management system, data modeling, relational database, structured query language, normalization, transaction, concurrency control, and recovery.

Course Objectives:

The main objective of this course is to provide fundamental concepts of database management system including data modeling, database design, SQL, transaction, concurrency control and database recovery.

Course Contents:

Unit 1 Introduction to Database and Database Users **2 hrs**

Introduction to Database, Database Management System; Database System Environment; Characteristics of Database Approach; Actors in Scene; Workers behind Scene; Advantages of DBMS

Unit 2 Database System Concepts **4 hrs**

Data Models, Schemas, Instances; Three Schema Architecture, Data Independence; DBMS Languages, DBMS Interfaces; Database System Environment; Centralized and Client/Server Architectures for DBMS; Classification of DBMS

Unit 3 Data Modelling using ER Model **7 hrs**

Data Models, Hierarchical Model, Network Model, Relational Model, Object Base Data Model, Entity Relationship Model; Entity Types, Entity Sets, Attributes, Keys, Relationship Types, Relationship Sets, Roles, Structural Constraints; Weak Entity Types; ER Diagrams, Naming Conventions, Design Issues; Relationship Types: Binary, Ternary, N-ary; Extended Entity Relationship, Subclasses, Superclasses, and Inheritance; Specialization and Generalization; Constraints and Characteristics of Specialization and Generalization, Union Types

Unit 4 Relational Data Model and Constraints **5 hrs**

Relational Model Concepts, Domains, Attributes, Tuples, Relations, Characteristics of Relations, Relational Model Notation; Relational Model Constraints and Relational Database Schemas, Domain Constraints, Key Constraints, Null Value Constraints, Relational Databases, Relational Database Schemas; Entity Integrity, Referential Integrity, Foreign Keys; Update Operations and Dealing with Constraint Violations, Insert, Delete and Update Operations, ER to Relational Mapping

Unit 5 Structured Query Language (SQL) **12 hrs**

Data Definition and Data Types, CREATE Schema, CREATE Table, Attribute Data Types and Domains; Specifying Constraints, Attribute Constrains and Defaults, Specifying Keys

and Referential Integrity Constraints, Naming Constraints, Constraint using CHECK; Basic Retrieval Queries, SELECT-FROM-WHERE, Ambiguous Attribute Name, Aliasing, Renaming, Unspecified WHERE Clause, Using Asterisk, Pattern Matching and Arithmetic Operators, ORDER BY; Complex Retrieval Queries, Dealing with NULL Values, Nested Queries, Correlated Nested Queries, EXISTS and UNIQUE Functions, Inner Join and Outer Joins, Aggregate Functions, GROUP BY and HAVING Clauses ; INSERT, DELETE, and UPDATE Statements; Views, DROP and ALTER Commands

Unit 6 Functional Dependencies and Normalization for Relational Databases 6 hrs

Informal Design Guidelines for Relational Schemas Insertion, Deletion, Modification Anomalies, Spurious Tuples; Functional Dependencies; Normalization, First, Second and Third Normal Forms; Boyce-Codd Normal Form; Multivalued Dependency and Fourth Normal Form; Properties of Relational Decomposition, Dependency Preservation, Nonadditive(lossless) Join Properties

Unit 7 Concepts of Transaction Processing 7 hrs

Introduction to Transaction Processing, Transactions, Database Items, Read Write Operations, Need of Concurrency Control, Need of Recovery; Transaction and System Concepts, Transaction States and Operations, Log, Commit Point; Properties of Transactions; Schedules, Conflicting Operations, Characterizing Schedules Based on Recoverability; Characterizing Schedules Based on Serializability, Serial, Non-serial and Conflict-Serializable Schedule, Conflict Equivalence, Serializable Schedules, Precedence Graph for Serializability Testing, Using Serializability for Concurrency Control

Unit 8 Concurrency Control and Database Recovery Techniques 5 hrs

Two-Phase Locking Techniques, Binary Locks, Shared/Exclusive Locks, Basic, Conservative, Strict, and Rigorous Two-Phase Locking; Deadlock and Starvation Timestamp Ordering, Timestamp, Timestamp Ordering Algorithm, for Concurrency Control Recovery Concepts, Immediate and Differed Updates, Buffering, Write Ahead Logging, Steal/No-Steal, Force/No-Force, Checkpoints, Cascading Rollback, NO-UNDO/REDO Recovery Based on Deferred Update; Recovery Technique Based on Immediate Update; Shadow Paging; Database Backup

Laboratory Works:

The laboratory work includes designing conceptual ER diagrams using some CASE tools. The laboratory work further should include writing database queries in SQL for creating databases, schemas, and tables, inserting values, updating, manipulating, altering and deleting data as well as databases, tables and schemas.

Reference Books:

1. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems; Seventh Edition, Pearson Education.
2. Avi Silberschatz, Henry F Korth, S Sudarshan, Database System Concepts, Seventh Edition, McGraw-Hill.
3. Raghu Ramakrishnan, Johannes Gehrke, Database Management Systems, Third Edition;; McGraw-Hill.
4. C. J. Date, An Introduction to Database Management Syste, 8th Edition, Pearson
5. Jaffrey D. Ullman, Jennifer Widom, A First Course in Database Systems, Third Edition, Pearson Education Limited.

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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Probability Distribution**
Nature: Theory+ Practical
Semester: II

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS153**
Credit Hours: 3

Course Description:
This course focuses on probability distribution related to fundamental statistical techniques that are of particular relevance to Data Science. The course covers random variables, mathematical expectation, discrete and continuous probability distributions, bivariate distributions and their applications.

Course Objectives:
After successful completion of the course, students will be able to

- Describe about probability distribution along with essential characteristics and properties
- Calculate and describe mathematical expectation and its properties
- Describe the characteristics features of and compute probabilities using discrete and continuous probability distributions
- Describe the bivariate distributions and calculate moments of bivariate distributions, conditional expectations, conditional variance
- Use Jacobian of transformations for bivariate distributions
- To apply these techniques in different scenario

Course Contents:

Unit 1 Random Variables **8 hrs**

Random variables and their properties, types of random variables: qualitative (Categorical) and quantitative, discrete and continuous random variables; Probability distribution of a random variable, probability mass function, probability density function and its properties, functions of random variable; Transformation of random variable; Joint probability mass function, joint probability distribution function, joint probability density function, conditional probability mass function and conditional probability density function. Solving Data Science related numerical problems

Unit 2 Mathematical Expectation **8 hrs**

Mathematical expectation of a random variable, properties of mathematical expectation, addition and multiplicative theorems of expectation, covariance and correlation, conditional expectation, conditional variance, variance of linear combination of random variables; Moments of random variables, raw and central moments; Generating functions: moment generating function, characteristic function, probability generating function, cumulant generating function with their properties. Solving Data Science related numerical problems**.**

Unit 3 Discrete Probability Distribution **10 hrs**

Binomial distribution, Poisson distribution, negative binomial distribution, geometric distribution, hyper-geometric distribution, negative hyper-geometric distribution: their mass functions, distribution functions, moments, moment generating functions, characteristic functions and properties, distribution fittings. Solving Data Science related numerical problems.

Unit 4 Continuous Probability Distribution **12 hrs**

Uniform distribution, Normal distribution, Lognormal distribution, Exponential distribution, Beta distribution, Gamma distribution, Weibull distribution; their density functions, distribution functions, moments, moment generating functions, characteristic functions, properties and uses with distribution fittings. Solving Data Science related numerical problems.

Unit 5 Bivariate Distribution **10 hrs**

Bivariate distribution for 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. Solving Data Science related numerical problems.

Laboratory Works:

The laboratory work includes using any statistical software such as Microsoft Excel, SPSS, R etc.

Practical Problems

S. No.	Title of the Practical Problems	No. of practical Problems
1	Random number generation, expectation, variance, covariance, raw and central moments.	3
2	Calculation of probabilities using Binomial distribution, Poisson distribution, negative binomial distribution and fitting of distributions	5
3	Calculation of probabilities using normal distribution, lognormal distribution, exponential distribution, and fitting of distributions	5
4	Calculation of descriptive statistics of probability distribution.	2

References Books:

1. Blitzstein Joseph K. & Hwang Jessica (2015). *Introduction to Probability*, CRC Press
2. Baron Michael (2014). Probability and Statistics for Computer Scientists, CRC Press
3. Gupta S. C. and Kapoor V. K. (2007). *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons
4. Rohatgi V. K. and Ehsanes Saleh, A. K. MD (2005). *An Introduction to Probability and Statistics*, John Wiley & Sons
5. Bruce Peter and Bruce Andrew (2017). *Practical Statistics for Data Scientists,* O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472, U.S.A.

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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Calculus II**
Nature: Theory
Semester: II

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS154**
Credit Hours: 3

Course Description:

This course is a continuation in Calculus I. It covers parametric equations and polar coordinates, infinite sequences and series, Fourier analysis. It also focuses on the comprehensive treatment of partial derivatives, optimization problems and multiple integrals.

Course Objectives:

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

- solve problems of infinite sequences and series
- obtain the elementary knowledge of Fourier series and Fourier transform
- to calculate derivatives of multivariable functions
- to solve the problems of double and triple integrals
- apply the techniques of calculus to solve real life problems.

Course Contents:

Unit 1 Parametric Equations and Polar Coordinates **8 hrs**

Curves defined by parametric equations, Calculus with parametric curves, Polar coordinates, Areas and lengths in polar coordinates, Conic sections, Conic sections in polar coordinates.

Unit 2 Infinite Sequences and Series **12 hrs**

Sequences, Series, Comparison tests, Alternating series, Absolute convergence, Ratio test, Root test, Integral test and estimates of sums, Power series, Taylor and Maclaurin series, Taylor polynomials and their applications.

Unit 3 Fourier Analysis **8 hrs**

Fourier series, Periodic functions, Odd and even functions, Fourier series for arbitrary range, Half range Fourier series, Fourier integral theorem, Fourier sine and cosine integral; Complex form of Fourier integral, Fourier transform, Fourier sine transform, Fourier cosine transform and their properties.

Unit 4 Partial Derivatives **11 hrs**

Functions of two and three variables, Limits and continuity, Partial derivatives, Higher order partial derivatives, Tangent planes and linear approximations, Directional derivatives and gradient vector, Total differentials, Euler's theorem of two and three variables, Maximum and minimum values, Lagrange multipliers.

Unit 5 Multiple Integrals **9 hrs**

Double integrals over rectangle, Iterated integrals, Double integrals over general regions, Double integrals in polar coordinates, Applications of double integrals, Triple integrals, Change of variables in multiple integral.

Reference Books:

1. Stewart J., Calculus: Early Transcendental Functions, 7th edition, Thomson Brooks/Cole.
2. Larson, et al, Calculus: Early Transcendental Functions, Houghton Mifflin, 2011.
3. Robert A. Adams, Christopher Essex, Calculus: a complete course, Pearson, 2010.
4. Kreyszig, E., Advance Engineering Mathematic, Tenth edition, Wiley, New York.

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Course of Study

Program: Bachelor in Data Science | *Full Marks*: 45+30
Paper: **Linear Algebra** | Pass Mark: 18+12
Nature: Theory | Course *Code*.: **BDS155**
Semester: II | *Credit Hours*: 3

Course Description:

This course emphasizing topics useful in other disciplines covers fundamental algebraic tools involving matrices and vectors to study linear systems of equations and linear transformations, eigenvalues and eigenvectors and their wide range of applications.

Course Objectives:

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

- use matrix and determinants to solve various mathematical and real life problems.
- acquire knowledge of vectors spaces and linear transformations.
- apply eigenvalues and eigenvectors in solving various problems.

Course Contents:

Unit 1 Matrix and Determinants **10 hrs**

Algebra of matrices, Determinants and its properties, Application of determinants, Complex matrices, Rank of matrices, System of linear equations and its matrix form, Row reduction and echelon forms, LU factorization.

Unit 2 Vectors Spaces **12 hrs**

Points in n-space, Algebra of points in n-space, Scalar and dot product, Norm and its properties, Distance, Angle between two vectors, Orthogonality, Scalar and vector projections, Cosines of lines, Projections, Vector spaces and subspaces, Linear combination, dependence and independence, Span, basis and dimension.

Unit 3 Linear Transformations **8 hrs**

Linear transformations, Kernel and image, Algebra of linear transformations, Matrix representation of a linear transformations, Four fundamental subspaces, Applications to difference equations, Applications to Markov chains.

Unit 4 Orthogonality **8 hrs**

Orthogonal vectors and sets, Orthogonal bases and Gram-Schmidt Process, QR-factorization, Least squares method.

Unit 5 Eigenvalues and Eigenvectors **10 hrs**

Eigenvalues and Eigenvectors, Cayley- Hamilton theorem and its application, Eigenvalue decomposition, Diagonalization of a matrix, Difference equations and powers A^k, Singular value decomposition.

Reference Books:

1. David C. Lay, *Linear Algebra and its Applications*, Pearson Education, 2012.
2. Gilbert Strang, *Introduction to Linear Algebra,* 4th Edition, Wellesley- Cambridge Press.
3. Howard Anton, Chris Rorres, *Elementary Linear Algebra*: *Applications Version,* Wiley, 2014.

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Course of Study

Program: Bachelor in Data Science
Paper: **Data Structure and Algorithms**
Nature: Theory+ Practical
Semester: **III**

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS201**
Credit Hours: **3**

Course Description:

This course provides a comprehensive study of different concepts of data structures and algorithms, focusing on their design, implementation, and analysis. Students will learn algorithm analysis, linked lists, stacks, queues, trees, searching, hashing, sorting, and graphs. This course also focuses on algorithm design techniques and strategies such as recursion, divide-and-conquer, dynamic programming, and greedy.

Course Objectives:

By the end of this course, students will be able to:

- Understand and implement fundamental data structures and their operations.
- Analyze algorithms for time and space efficiency.
- Understand and implement linked lists, stacks, queues, trees, and graph structures.
- Implement searching, sorting and hashing techniques.
- Understand and use algorithm design techniques and strategies.

Course Contents:

Unit 1 Introduction to Algorithm Design **3 hrs**

Introduction to Algorithms; Performance Analysis (Time Complexity, Space Complexity); Asymptotic Notations (Theta Notation, Big O Notation, Omega Notation); Amortized Analysis; Composing Complexity Classes; Computing Running Time Complexity of an Algorithm.

Unit 2 Linked List **8 hrs**

Array; Introducing Linked List (Nodes, Pointers); Singly Linked Lists (Creating, Traversing, Inserting, Querying, Deleting); Doubly Linked Lists (Creating, Traversing, Inserting, Querying, Deleting); Circular Lists (Creating, Traversing, Inserting, Querying, Deleting); Practical Applications.

Unit 3 Stacks and Queues **6 hrs**

Stacks (Introduction and Operations, Stack Implementation using Arrays, Stack Implementation using Linked Lists, Stack Applications (Bracket Matching, Infix to Postfix Conversion, Postfix Evaluation); Queues (Introduction and Operations, Queue Implementation using Array, Queue Implementation using Linked List); Priority Queue; Queue Applications.

Unit 4 Trees **7 hrs**

Introduction and Terminologies; Binary Tree (Node Implementation, Tree Traversal, Expression Trees); Binary Search Tree (Introduction, Operations, Benefits); AVL Tree; Heap Data Structure.

Unit 5 Searching and Hashing **6 hrs**

Sequential Search; Binary Search; Hashing; Hash Function; Perfect Hash Function, Collision Resolution Techniques (Linear Probing, Quadratic Probing, Double Hashing, Separate Chaining).

Unit 6 Sorting **5 hrs**

Sorting Algorithms; Bubble Sort; Insertion Sort; Selection Sort; Merge Sort; Quick Sort; Heap Sort.

Unit 7 Graphs **8 hrs**

Introduction and Terminologies; Directed and Undirected Graphs; Directed Acyclic Graphs; Weighted Graphs; Bipartite Graphs; Graph representations (Adjacency Lists, Adjacency Matrix); Graph Traversals (Breadth-First Search, Depth-First Search); Shortest-Path Algorithm; Minimum Spanning Tree (Kruskal's Algorithm, Prim's Algorithm).

Unit 8 Algorithm Design Techniques and Strategies **5 hrs**

Algorithm Design Techniques; Recursion; Divide and Conquer; Dynamic Programming; Greedy Algorithms.

Laboratory Works:

Laboratory work includes writing programs using Python programming language to implement data structures and algorithms studied in each unit of the syllabus. Special focus will be given to implement inked list, stack, queue, tree, searching, sorting, hashing, graphs and related algorithms.

Reference Books:

1. Agarwal, B. (2022). Hands-On Data Structures and Algorithms with Python. Third Edition. Packt Publishing.
2. Canning, J., Brode, A. and Lafore, R. (2023). Data Structure and Algorithms in Python. Pearson Education.
3. Goodrich, M.T., Tamassia, R. and Goldwasser, M. H. (2021). Data Structure and Algorithms in Python. Wiley.

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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Operating System**
Nature: Theory+ Practical
Semester: **III**

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS202**
Credit Hours: **3**

Course Description:

The course covers fundamental concepts of operating system as well as, Process management, Memory management, File systems, and I/O Managements and Disk Managements.

Course Objectives:

The main objective of this course is to introduce different concepts of operating system and its components and functions.

Course Contents:

Unit 1 Introduction to Operating System **6 hrs**

Abstract view of Computer system, Introduction of Operating System, OS as Extended Machine and Resource Manager, Evolution of Operating System, Types of OS, Function of Operating System, System Call, Operating System Structures (Layered, Monolithic, Microkernel), Kernel, Shell Case Study: UNIX, LINUX, Windows.

Unit 2 Processes Management **12 hrs**

Process, Process and Program, 5 State Process Model, Process Creation, Process Control Block, Context Switching, Threads, Thread vs Process, User and Kernel Level Threads

Inter Process Communication: Race Condition, Mutual Exclusion, Critical Regions, Implementing

Mutual Exclusion: Mutual Exclusion with Busy Waiting (Disabling Interrupts, Lock Variables, Strict Alteration, Peterson's Solution, Test and Set Lock), Producer Consumer Problem, Semaphore, Operation on Semaphore, Solution to producer consumer problem using Semaphore, Message Passing, Classical IPC problem: Dining Philosopher Problem, Readers Writer, Sleeping Barber (Concept Only)

Process Scheduling: Introduction, Preemptive and non Preemptive Scheduling, Scheduling Criteria, Batch System Scheduling (First-Come First Served, Shortest Job First, Shortest Remaining Time Next), Interactive System Scheduling (Round-Robin Scheduling, Priority Scheduling), Multilevel Scheduling Concept.

Unit 3 Deadlocks **6 hrs**

Introduction, Deadlock Characterization, Preemptable and Non-preemptable Resources, Resource Allocation Graph, Conditions for Resource Deadlock, Handling Deadlocks: Ostrich Algorithm, Deadlock prevention, Safe and Unsafe state, Deadlock Avoidance: Banker' Algorithm, Deadlock Detection, Recovery from Deadlock (Through Preemption and Rollback)

Unit 4 Memory Management **10 hrs**

Introduction, Logical and Physical Address Spaces, Monoprogramming vs. Multi-programming, Modelling Multiprogramming, Relocation and Protection, Memory Management with Swapping: Bitmaps and Linked-list), Memory Allocation Strategies: Fixed-partition and Variable-partition strategies.

Virtual memory: Paging, Page Table, Structure of Page Table, Multilevel Page Table, Logical to Physical Address Translation, TLB, Page Fault, Handling Page Faults, Page Replacement Algorithms: FIFO, LRU, Optimal, LFU, Second Chance and Replacement, Concept of Locality of Reference, Segmentation, Segmentation with Paging (Multics).

Unit 5 File Management **6 hrs**

File Overview: File Naming, File Structure, File Types, File Access, File Attributes, File Operations, Single Level, two Level and Hierarchical Directory Systems, File System Layout, Implementing Files: Contiguous allocation, Linked List Allocation, Inode, Directory Operations, Path Names, Directory Implementation, Shared Files, Free Space Management: Bitmaps, Linked List, Case Study: UNIX File Management, Linux Virtual File System, Windows File System.

Unit 6 Device Management **6 hrs**

Classification of I/O devices, Controllers, Memory Mapped I/O, DMA Operation, Goals of I/O Software, Handling I/O (Programmed I/O, Interrupt Driven I/O, I/O using DMA), I/O Software Layers (Interrupt Handlers, Device Drivers)

Disk Structure, Disk Scheduling (FCFS, SSTF, SCAN, CSCAN, LOOK, CLOOK), Disk Formatting (Cylinder Skew, Interleaving), RAID, RAID Levels (Up to 5).

Unit 7 Distributed Operating System **2 hrs**

Basic Concepts of Distributed System, Design Goals, Types of Distributed System.

Laboratory Works:

The laboratory work includes solving problems in operating system covering all the listed topics in the syllabus.

Lab Manual:

- LINUX and MS-DOS Commands
- Process creation, termination in any operating system
- Thread Creation using POSIX Library
- Implementation of process scheduling algorithms
- Implementation of solution to critical section problem
- Implementation of Banker algorithm
- Implementation of memory allocation techniques
- Implementation of page replacement algorithm
- Implementation of disk scheduling algorithm

Reference Books:

1. Andrew S. Tanenbaum, Modern Operating Systems, 2nd Edition, Prentice-Hall.
2. Silberschatz, Galvin and Gagne, Operating System Concepts, 6th Edition, Addition Wesley.
3. Stallings, W. (2009). *Operating systems: Internals and Design Principles*. Prentice Hall.
4. Van Steen, M., & Tanenbaum, A. S. (2017). *Distributed systems*. Create space Independent Publishing Platform.

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Course of Study

Program: Bachelor in Data Science
Paper: **R Programming**
Nature: Theory+ Practical
Semester: **III**

Full Marks: 45+30
Pass Mark: 18+12
Course *Code*.: **BDS203**
Credit Hours: **3**

Course Description:

This is an introductory course on R programming and statistical analysis by using R programming. This course is intended as a guide to data management, manipulation and analysis with the R programming. This course covers an introduction to R, the R basics, logical operator, data structure, data management in R, matrix operation, data visualization and graphics in R, and basic statistical functions, inferences by using R programming.

Course Objectives:

After completion of this course, the students will be able:

- to understand the basics of R
- to operate vector and matrix by using R
- to manipulate and transform the data by using R
- To illustrate data in graphs and charts by using R
- to use R for various statistical computations and inferences
- to apply R to compute correlation and regression

Course Contents:

Unit 1 An introduction to R and Data Structure in R **7 hrs**

Purpose of using R software, installing R and RStudio, The R environment and working with R, The R packages (Meaning and purpose of packages, installing, loading and learning Packages), Basic math, variables, data types, basic R function, List, Vectors, Matrices, Arrays, Data Frames, Factors, Organizing work in R and RStudio and making it reproducible (R Script, R markdown documents).

Unit 2 Conditional and Control Flow in R **3 hrs**

Relational operators and vectors, Logical operations (AND, OR, NOT), Logical operators and vectors, inbuilt command, packages, control statements (conditional statements and loops).

Unit 3 Data Input and Management in R **12 hrs**

Data entering, Data reading from external files (CSVs, Excel, SPSS, Stata files), creating new variables, recoding variables, renaming variables, missing values, sorting data, merging data sets (Adding columns and rows to the data frame), manipulating and tyding data in R, concept about tidyverse, and dplyr packages, sub setting, selecting variables, dropping variables, selecting observations, dplyr functions, data manipulation by using dplyr, data wrangling in R, data transformation in R, working with pipes.

Unit 4 Matrix Operation **4 hrs**

Matrix operations, creating matrix from vector, combine vectors or matrices, matrix addition, transpose matrix, Find the dimension of a matrix or dataset, matrix multiplication, finding the inverse of a matrix, component-wise multiplication, create a submatrix, create a diagonal matrix, a vector of diagonal elements, create a vector from a matrix, calculate the determinant, find eigenvalues and eigenvectors, find the singular value decomposition.

Unit 5 Graphics, Visualization and Summary Measures **8 hrs**

Bar chart, pie chart, box plot, histogram, line graph, density plots, Normal Q-Q plot, Scatter plot, basics of ggplot: introduction to grammar of ggplot, univariate and multivariate charts (bar chart, pie chart, box plot, histogram (along with density plot), line graph, scatter plot by using ggplot, measures of central tendency, measures of variation, measures of skewness and Kurtosis, apply, lapply and sapply, summary measure and variability by dplyr.

Unit 6 Probability and Probability distribution in R **4 hrs**

Random Number, random number generator, sample selection, binomial distribution, negative binomial distribution, poisson distribution, normal distribution, plot for testing normality.

Unit 7 Statistical Inference by using R **6 hrs**

Idea about inferential analysis, hypothesis testing, null and alternative hypothesis, decision by critical value and p-value approaches, inferences in the one sample case, student's t distribution, comparing two variances (Fisher's F test), comparing two sample means(independent sample t test), paired sample t test, comparing three or more means (F test), testing for independence in contingency tables using chi-squared.

Unit 8 Correlation and Regression Analysis by using R **4 hrs**

correlation coefficient, test of correlation coefficient, correlation matrix by using R/R studio, linear regression, assumptions, unstandardized coefficient, standardized coefficient, hypothesis testing of individual regression coefficient (t test), overall test (f test), multiple coefficient of determination, standard error by using R/R studio.

Laboratory Work:

The Laboratory work includes solving problems in R Programming covering all the units of the syllabus.

References Books:

1. Crawley, M.J. (2015). *Statistics An Introduction Using R*, Second Edition, John Wiley & Sons Ltd London, UK.
2. Dalgaard, P. (2008): *Introductory Statistics with R*, Second Edition, Springer. Kabacoff, R.I. (2015): *R in Action Data analysis and graphics with R, Second Edition*, Manning Publications Co.
3. Lander. J.P. (2014). *R for Everyone: Advanced Analytics and Graphics.* Pearson Education.
4. Thomas, M. (2017): *Beginning Data Sciences in R: Data Analysis, Visualization, and Modelling for the Data Scientists*. Apress, Denmark.

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Course of Study

Program: Bachelor in Data Sciences
Paper: **Inferential Statistics**
Nature: Theory+ Practical
Semester: **III**

Full Marks: 45+30
Pass Marks: 18+12
Code No.: **BDS204**
Credit: **3**

Course Description:

This course focuses on inferential statistical techniques that are relevant to Data Science. The course covers random sampling & sampling distribution, estimation, testing of hypothesis, different statistical tests and their applications.

Course Objectives:

After successful completion of the course, students will be able to

- Describe and calculate sampling distribution of sample mean, sample variance and sample proportion.
- Describe and apply the principles of inferential statistics.
- Understand and apply different statistical prospects of point estimation and interval estimation.
- Apply sample size estimation technique under different scenario.
- Explain the fundamental concepts of testing of hypothesis and linkage between confidence interval estimation and testing of hypothesis.
- Apply different statistical tests appropriately focusing in the research problems related to data science

Course Contents:

Unit 1 Random Sampling and Sampling Distributions **12 hrs**

Definition of random sample, parameter and statistics, sampling distribution of the sample mean, proportion and sample variance (SRS with /without replacement), standard errors of sample mean and sample proportion, concept of Central Limit Theorem (CLT) and its applications, independence of sample mean and sample variance. Exact sampling distributions: Definition of central χ^2, t and F and their properties, inter-relation between the distributions, application of χ^2, t and F distributions in statistics.

Unit 2 Estimation **16 hrs**

Point Estimation: Estimation of parameter, characteristic and properties of a good estimator (unbiasedness, consistency, efficiency, sufficiency), likelihood function and properties; method of estimation: method of maximum likelihood estimation (Binomial, Poisson and Normal), method of minimum variance and method of moments and their properties, Cramer-Rao inequality

Interval Estimation: Confidence intervals of mean and difference of means, Confidence intervals for proportion and difference of proportions. Confidence interval for a difference between two means for paired data, confidence interval estimate of correlation, regression coefficients and average value of dependent variable, approximate prediction interval of dependent variable, determination of sample size to estimate mean and proportion, problem specific interpretation of confidence interval.

Unit 3 Theory of Hypothesis Testing **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, use of critical value and p-value approach in testing of hypothesis, likelihood ratio test and its properties, different scenario of using the concept of testing of hypothesis in data science related problems

Unit 4 Statistical Tests **12 hrs**

Need and importance of statistical tests, test of significance of mean (single and double samples, large and small samples, independent and dependent samples), test of significance of proportion (single and double samples), test significance of sample variance (Chi-square test), test significance of two sample variances, and overall fit of the regression model (F-test), One way and two way Analysis of Variance (ANOVA), test of significance of correlation coefficient and regression coefficients, assumptions for applying statistical tests, applications of different statistical tests in data science related numerical problems

Laboratory Works:

The laboratory work includes using any statistical software such as Microsoft Excel, SPSS, R etc.

Practical Problems

S. No.	Title of the Practical Problems	No. of practical Problems
1	Sampling distribution of mean and proportion, standard error and determination of sample size	1
2	Confidence intervals of mean and difference of means. Confidence intervals for proportion and difference of proportions. Confidence interval for a difference between two means for paired data, confidence interval estimate of correlation, regression coefficients (interval estimation)	4
3	Parametric test (covering most of the tests)	8
4	Chi-square test	2

Reference Books:

1. Bruce Peter and Bruce Andrew (2017). *Practical Statistics for Data Scientists*, O'Reilly Media, Inc.
2. Gupta S. C. and Kapoor V. K. (2007). *Fundamentals of Mathematical Statistics,* Sultan Chand and Sons, India.
3. Hogg Robert V. McKean Joseph W. and Criag Allen T.(2019). *Introduction to mathematical statistics*, 8th edition, Pearson Education Inc.
4. Mayer, P. L. (1970). *Introductory Probability and Statistical Applications*, second edition Oxford and IBH Publishing Co. Pvt Ltd, New Delhi.
5. Nitis Mukhopadhyay (2000). *Probability and Statistical Inference*, CRC Press Taylor & Francis Group.
6. Rohatgi, V. K. (1984). *Statistical Inference*, Wiley, New York.

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Course of Study

Program: Bachelor in Data Science | *Full Marks*: 45+30
Paper: **Differential Equations** | *Pass Marks*: 18+12
Nature: Theory | *Code No.*: **BDS205**
Semester: **III** | *Credit*: **3**

Course Description:

This course introduces differential equations and their applications. It covers first, second and higher order differential equations. It also includes system of first order linear equations, series solution of second order linear equations, Laplace transform and their applications.

Learning Objectives:

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

- Solve first, second and higher order differential equation.
- Solve system of first order linear equations.
- Apply Laplace transform in solving initial value problems.

Course Contents:

Unit 1 First Order Differential Equations **12 hrs**

Differential equations and its classification, Solution of differential equations, Some basic mathematical models and direction fields, Separable equations, Homogeneous differential equations, Exact equations, Linear equations, Bernoulli equations, Modeling with first order equations, Autonomous differential equations and population dynamics, Numerical approximations: Euler's method, Existence and uniqueness theorem, First order higher degree differential equations.

Unit 2 Second and Higher Order Linear Equations **12 hrs**

Second order linear equations: Homogeneous equations with constant coefficients, Solution of linear homogeneous equations; Wronskian, Real and complex roots of the characteristic equation, Reduction of order, Non-homogeneous equations; Methods of undetermined coefficients and variation of parameters.

Higher order linear equations: General theory of n^{th} order linear equations, Homogeneous differential equations with constant coefficients, Methods of undetermined coefficients and variation of parameters.

Unit 3 Series Solution of Second Order Linear Equations **8 hrs**

Series solutions near an ordinary point, Regular and irregular singular points, Euler equations, Series solutions near a regular singular point, Bessel's equation.

Unit 4 System of First Order Linear Equations **6 hrs**

Systems of linear algebraic equations; Linear independence, eigenvalues, eigenvectors, Basic theory of first order linear equations, Homogeneous linear system with constant coefficients, Complex eigenvalues.

Unit 5 Laplace Transform **10 hrs**

Laplace transform and its properties, Inverse Laplace transform and its properties, Step functions, Differential equations with discontinuous forcing functions, Impulse functions, Convolution integral, Application of Laplace transform to initial value problems.

Reference Books:

1. Boyce, W.E., DiPrima, R.C and Meade D.B., *Elementary Differential Equations and Boundary Value Problems*, 9th edition., Wiley India Pvt. Ltd.
2. James C. Robinson, *An Introduction to Ordinary Differential Equations*, Cambridge University Press.
3. Shepley L. Rose (2010), *Differential Equations*, 3rd edition, James Wieley India.

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Tribhuvan University
Institute of Science and Technology

SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Seminar**
Nature: Seminar
Semester: **III**

Full Marks: 25
Pass Mark: 10
Course *Code*.: **BDS206**
Credit Hours: **1**

Course Description:

The seminar course provides an overview of data science concepts, tools, and applications, with a focus on current trends and research. Students will explore the data science and related field. The course emphasizes research, presentation skills, and critical evaluation of data-driven insights. Each student will prepare an individual seminar report on emerging topics in data science, fostering understanding of both technical and practical aspects of the field. The students will also present the seminar report in the school. Once accepted, the students will have to submit the final copy of the report in the school.

Course Objectives:

By the end of the course, students should be able to:

- Understand the scope and fundamentals of data science and related fields.
- Explore emerging trends, tools, and applications in data science.
- Conduct research and critically evaluate data-driven insights from literature and datasets.
- Develop effective presentation and communication skills for technical content.
- Prepare a structured seminar report demonstrating both theoretical understanding and practical analysis.
- Engage in academic discussions and defend their findings during presentations.

Report Structure:

1. Title Page
2. Abstract
3. Table of Contents
4. Introduction
   - **4.1.** Background and Motivation
   - **4.2.** Problem Statement
   - **4.3.** Objectives
5. Literature Review / Related Work
6. Methodology
7. Results and Discussion
8. Conclusion
9. References

Report Format:

- **Page Numbers:** The pages after title page and before introduction should be numbered in roman starting from i. The pages starting from Introduction onwards should be numbered in numeric starting from 1. Page numbers should be inserted at the bottom of the page and aligned centre.
- **Page Size and Margin:** The paper size should be A4 and the margins must be set as:
  Top = 1 inch
  Bottom = 1 inch
  Left = 1.25 inches
  Right = 1 inch

- **Paragraph:** All paragraphs must be indented and justified (both left-justified and right-justified). All the paragraphs must be written using Times New Roman font with font size 12 and 1.5 paragraph spacing.
- **Heading:** No more than 3 levels of headings should be used. Font size for the heading should be 16 for chapter title, 14 for section headings and 12 for subsection headings. All the headings should be written using Times New Roman font with bold faced.
- **Figures and Tables:** Figure captions should be centred below the figures and table captions should be centred above the table. All captions should be written using Times New Roman with font size 12, bold faced and centre alignment.
- **References:** References provide a list of papers, books and other publications that are explicitly referred to in the text. The report should follow latest version of *APA style* of citations and references.

Evaluation:

Final examination of the seminar will be evaluated by Project and Internship Evaluation Committee of the School by taking the individual oral presentation and viva in a relevant topic or issue related to data silence on the prescribed evaluation format prepared by the School. The evaluation format includes the quality of the seminar report prepared by the students and its relevancy, depth of work, presentation skill and response of query.

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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Artificial Intelligence**
Nature: Theory + Practical
Semester: **IV**

Full Marks: 45+30
Pass Marks: 18+12
Code No.: **BDS251**
Credit: **3**

Course Description:

The course introduces the fundamental concepts of artificial intelligence. It includes the basics of artificial intelligence, intelligent agents, problem solving using searching, informed and uninformed search techniques, adversarial searching, knowledge representation systems, machine learning, expert system, natural language processing, computer vision, AI ethics and advanced concepts in AI.

Course Objectives:

Upon successful completion of this course, students will be able to:

- Acquaint with the concepts of artificial intelligence
- Configure intelligent agents
- Solve problems using search techniques
- Represent knowledge in AI systems
- Understand the basics of machine learning
- Design expert systems
- Perform basic operations of NLP
- Understand concept of computer vision
- Know about the AI ethics
- Get familiar with advances in AI

Course Contents:

Unit 1 Introduction **6 hrs**

Artificial Intelligence (AI); AI Dimensions: Acting Humanly, Thinking Humanly, Acting Rationally, Thinking Rationally; Foundations of AI; History of AI;

Agents; Rational Agents; PEAS Description; Environment Types; Agents Types: Simple Reflex, Model Based, Goal Based, Utility Based, Learning Agent;

Unit 2 Problem Solving by Searching **11 hrs**

Problem Solving Agents; Search Problems and Solutions; State Space Representation; Problem Formulation; Solving Problems by Searching;

Search Algorithms; Measuring Problem Solving Performance;

Uninformed Search Strategies: Breadth First Search, Depth First Search, Depth Limited Search; Iterative Deepening Search, Bidirectional Search;

Informed Search Strategies: Greedy Best First Search, A* Search;

Local Search Strategies: Hill Climbing Search, Simulated Annealing;

Adversarial Search; Mini-Max Search, Alpha-Beta Pruning;

Constraint Satisfaction Problems; Examples of Constraint Satisfaction Problems;

Unit 3 Knowledge Representation and Reasoning **10 hrs**

Knowledge and Knowledge Representation; Knowledge Representation Systems;
Logic Based Knowledge Representation: Propositional and Predicate; Propositional Logic: CNF Form; Resolution Algorithm in Propositional Logic; Predicate Logic: FOPL; Quantifiers in FOPL; Reasoning in FOPL: Unification and Lifting, Inference using Resolution in FOPL
Semantic Nets, Frames, Rule Based Systems,
Uncertain Knowledge, Prior and Posterior Probability, Inference using Full Joint Distributions, Bayes' Rule; Bayesian Networks

Unit 4 Machine Learning **6 hrs**

Machine Learning; Supervised Learning; Unsupervised Learning; Reinforcement Learning; Artificial Neural Network (ANN);Learning with Genetic Algorithms;

Unit 5 Applications of AI **7 hrs**

Expert Systems; Architecture of Expert System;
Natural Language Processing: Steps of Natural Language Processing;
Robotics; Robot Hardware; Robotic Perception; Planning and Control;
Computer Vision; Components of Computer Vision

Unit 6 AI Ethics **3 hrs**

Ethics of AI; Lethal Autonomous Weapons; Surveillance, Security, and Privacy; Fairness and Bias; Trust and Transparency; Future of Work; Robot Rights; AI Safety.

Unit 7 Advanced Concepts in AI **5 hrs**

Deep learning; Generative AI; Explainable AI; Multimodal AI; Generative Adversarial Networks; Large Language Models; Prompt Engineering; Quantum AI

Laboratory Works:

The laboratory work consists of implementation of Intelligent Agents, Constraint Satisfaction Problems, Blind and Heuristic Search Algorithms, Knowledge Representation Systems, Artificial Neural Networks, Expert Systems, Basics of Natural Language Processing.

Reference Books:

1. Stuart Russel and Peter Norvig (2022). *Artificial Intelligence A Modern Approach*, Pearson.
2. Kevin Knight, Elaine Rich and Shivashankar B. Nair (2017). *Artificial Intelligence*, Tata McGraw Hill.
3. Rajiv Chopra, *Artificial Intelligence*, S Chand Publication
4. Gaurav Leekha (2021). *Learn AI with Python*, BPB Publication.
5. George F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, Benjamin/Cummings Publication
6. D. W. Patterson, *Artificial Intelligence and Expert Systems*, Prentice Hall.
7. P. H. Winston, *Artificial Intelligence*, Addison Wesley.

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Tribhuvan University
Institute of Science and Technology

SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science | *Full Marks*: 45+30
Paper: **Web Development** | *Pass Marks*: 18+12
Nature: Theory + Practical | *Code No.*: **BDS252**
Semester: **IV** | *Credit*: **3**

Course Description:

This course covers both front-end and back-end aspects of modern web development. Students will learn different concepts of web development and concepts of HTML, CSS, JavaScript, PHP, and working with databases. By the end of the course, learners will be able to design, develop, and deploy functional web applications that meet industry standards.

Course Objectives:

By the end of this course, students will be able to:

- Understand the fundamental concepts, architecture, and protocols of the web.
- Develop responsive, interactive and dynamic web pages using HTML, CSS, JavaScript and PHP.
- Integrate databases with web applications for data storage and retrieval.
- Utilize version control tools for collaboration and project management.
- Deploy and maintain websites on web servers or cloud platforms.

Course Contents:

Unit 1 Introduction to Web Development **4 hrs**

The Internet; Client / Server Architecture; World Wide Web; Uniform Resource Locator; Domain Name System; Wet Client and Web Server; HTTP Request and Response; Static vs Dynamic Web Sites; Client-Side and Server-Side Scripting; Web 1.0, Web 2.0, and Web 3.0.

Unit 2 HyperText Markup Language **10 hrs**

HTML Introduction; Structure of HTML Document; Elements and Attributes; Comments; Headings; Paragraphs; Text Formatting; Line Break; Quotations; Links; Images; Tables; Lists; Block and Inline Elements; Iframes; Forms; Audio and Video.

Unit 3 Cascading Style Sheets **6 hrs**

CSS Introduction; Syntax; Selectors; Ways of Inserting CSS; Comments; Colors and Backgrounds; Texts and Fonts; Box Model; Display and Positioning; Lists and Tables; Combinators; Pseudo-classes and Pseudo-elements; Flexbox; Grid; Transitions and Animations; Transformations; Responsive Web Design; Media Queries.

Unit 4 Client-Side Scripting **11 hrs**

Introduction of JavaScript, Basic Syntax, Variables and Data Types, Statements, Operators, Literals, Control Statements, Functions, Objects, Arrays, Built-in Objects, Strings, Forms; Cookies; DOM, BOM, AJAX, Introduction to XML, JQuery, and JSON; Basics of Client-Side Frameworks.

Unit 5 Server-Side Scripting **14 hrs**

Introduction to PHP; Syntax; Variables; Data Types; Operators; Control Statements; Functions; Arrays; Classes and Objects; Strings; Superglobals; Forms; File Handling; Cookies; Session; Error and Exception; Database Handling; Basics of Server-Side Frameworks.

Unit 6 Hosting and Deployment **3 hrs**

Git and GitHub Basics; Full-Stack Development; Hosting and Deployment Platforms; Choosing a Hosting Provider; Obtaining Domain Name; Uploading Files to Servers

Laboratory Works:

Laboratory work includes creating web pages using HTML, CSS, JavaScript, and PHP. At the end this course, students will be able to build a complete web project that includes front-end, back-end, database, and deployment.

Reference Books:

1. Ackermann, P. (2023). Full Stack Web Development: The Comprehensive Guide. Rheinwerk Computing.
2. Duckett J. (2022). Front-End Back-End Development with HTML, CSS, JavaScript, jQuery, PHP, and MySQL. Wiley.
3. Wenz, C. & Hauser, T. (2025). PHP and MySQL: The Comprehensive Guide. Rheinwerk Computing.
4. Wolf, J. (2023). HTML & CSS: The Comprehensive Guide. Rheinwerk Computing.
5. McGrath, M. (2020). HTML, CSS & JavaScript in Easy Steps. in Easy Steps Limited.
6. Robbins, J. N. (2018). Learning Web Design: A Beginner's Guide to HTML, CSS, JavaScript, and Web Graphics, O'Reilly Media.

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Tribhuvan University
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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Data Communications and Computer Networking**
Nature: Theory + Practical
Semester: **IV**

Full Marks: 45+30
Pass Marks: 18+12
Code No.: **BDS253**
Credit: **3**

Course Description:

This course focuses on essential theories surrounding data communication, transmission, and computer networking. It systematically examines the roles and functions of each OSI layer- from the Physical and Data Link layers up through the Network and Transport layers, concluding in the Application layer.

Course Objectives:

The main objective of this course to make the students understand the distinction and conversion between analog and digital signals, and their methods of transmission; analyze and apply major network protocols including the OSI and TCP/IP models; evaluate different transmission media and characterize their properties; explain various multiplexing techniques (e.g., FDM, TDM); evaluate switching techniques such as circuit switching and packet switching; implement error detection and correction strategies to ensure data integrity; understand concepts of data link control for managing link-level communication; apply routing algorithms to determine efficient data paths in networks; understand and use transport layer protocols including mechanisms for congestion control; explore critical application-layer services.

Course Contents:

Unit 1 Introduction to Data Communication **6 hrs**

Overview of Data Communications: Components, Message, Data Flow; Overview of Networks: Network Criteria, Physical Structures; Network Type: LAN, WAN, Internetwork, The Internet, Accessing the Internet; Protocol Layering: Single-Layer, Multi-Layer; Principles of Protocol Layering, Logical Connections, TCP/IP Protocol Suite and Description of Each Layer; OSI Model and Description of Each Layer; OSI Versus TCP/IP

Unit 2 Physical Layer **10 hrs**

Introduction; Signals: Analog Signals, Digital Signals; Signal Impairments; Data Rate Limits; Performance; Digital Transmissions; Analog Transmissions; Analog-to-Analog Conversion; Multiplexing; Transmission Media;

Unit 3 Data Link Layer **10 hrs**

Introduction; Data Link Control: Framing, Error Control; Overview of HDLC and PPP; Media Access Protocols; Link Layer Addressing

Unit 4 Network Layer **10 hrs**

Introduction; Services; Packet Switching; Performance; Internet Protocol Version 4: IPv4 Addressing, Main and Auxiliary Protocol, Options, Security of IPv4 Datagrams, General Format and Basic Overview of ICMP messages; Introduction of IPv6, Basic Overview of ICMPv6 messages; Transition from IPv4 to IPv6; Routing Algorithms; Unicast Routing Protocols; Multicast Routing.

Unit 5 Transport Layer **6 hrs**

Introduction; Transport Layer Services; Transport Layer Protocols, User Datagram Protocol; Transmission Control Protocol.

Unit 6 Application Layer **6 hrs**

Introduction; Client/Server Paradigm; Standard Applications.

Laboratory Works:

Cabling: Straight Cable, Cross Cable; Basic LAN Setup and Introduction to Basic Network Commands; Packet Sniffing with Wireshark: Capture and Analyze Packets for HTTP, TCP, UDP, ICMP, Filter Packets and Inspect Headers; Installation and Configuration of DNS, DHCP and File Server

Reference Books:

1. Forouzan, B. A. (2022). *Data communications and networking with TCP/IP protocol suite* (6th ed., International student ed.). McGraw-Hill.
2. Stallings, W. (2022). *Data and computer communications* (Indian ed.). Pearson Education.
3. Tanenbaum, A. S., Wetherall, D. J., & Feamster, N. (2021). *Computer networks* (6th ed., Global ed.). Pearson Education.

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Tribhuvan University
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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science | *Full Marks*: 45+30
Paper: **Discrete Mathematics** | *Pass Marks*: 18+12
Nature: Theory | *Code No.*: **BDS254**
Semester: **IV** | *Credit*: **3**

Course Description:

This course deals with mathematical structures that are discrete in nature rather than continuous. It covers the key combinatorial topics of combinatorial enumeration and is useful and accessible for applied fields. It has many real-world applications that can be explained using only a few simple definitions. Elementary number theory, Modular arithmetic, Induction, Counting techniques, Recurrence relations 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

- Use Modular arithmetic
- Work with prime numbers and the fundamental theorem of arithmetic,
- Solve systems of linear congruences and counting problems.
- Apply the principles of mathematical induction in proofs.
- Model with recurrence relations

Course Contents:

Unit 1 Logic and Proofs 9 **hrs**

Propositional logic, Application of propositional logic, Propositional equivalences, Predicates and quantifiers, Nested quantifiers, Rules of inference, Introduction to proofs, Proof methods and strategy.

Unit 2 Number Theory 9 **hrs**

Divisibility and modular arithmetic, Integer representations and algorithms, Primes and greatest common divisors, Solving congruences, Applications of congruences, Cryptography.

Unit 3 Induction and Recursion **9 hrs**

Mathematical induction, Strong induction and well-ordering, Recursive definitions and structural induction, Recursive algorithms.

Unit 4 Counting Techniques **13 hrs**

Basics of counting, Pigeonhole principle, Permutations and combinations, Binomial coefficients and identities, Generalized permutations and combinations, Recurrence relations and its applications, Solving linear homogeneous recurrence relations with constant coefficients, Linear non homogeneous recurrence relations with constant coefficients, Generating functions, Inclusion-exclusion.

Unit 5 Relations **8 hrs**

Relations and their properties, n-ary relations and their applications, Representing relations, Closures of relations, Equivalence relations, Partial orderings.

Reference Books:

1. Kenneth H. Rosen, *Discrete Mathematics and its Applications, 8th* edition, McGraw Hill, New York.
2. Susanna S. Epp (2011). *Discrete Mathematics with Applications,* Brooks/Cole.
3. Kevin Ferland (2009). *Discrete Mathematics an Introduction to Proofs and Combinatorics,* Houghton Mifflin Company.
4. Peter J. Cameron (1995). *Combinatorics: Topics, Techniques, Algorithms,* CUP.
5. Dieter Jungnickel (2005). *Graphs, Networks, and Algorithms,* Springer.
6. Ian Anderson (2001). *A First Course in Discrete Mathematics,* Springer.
7. Alan Camina and Barry Lewis (2011). *An Introduction to Enumeration*, Springer.

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SCHOOL OF MATHEMATICAL SCIENCES

Course of Study

Program: Bachelor in Data Science
Paper: **Technical Writing**
Nature: Theory
Semester: **IV**

Full Marks: 45+30
Pass Marks: 18+12
Code No.: **BDS255**
Credit: **3**

Course Description:

This course introduces students to technical and professional writing. It covers the full development process of technical documentation, including planning, writing, visual design, editing, indexing, and production. Students will gain practical insights into communicating in workplace environments and technical discourse communities, such as those in data analysis and scientific research. Key genres include emails, letters, resumes, memos, reports, proposals, technical descriptions, definitions, and manuals. To align with real-world applications, emphasis is placed on skills beyond writing, such as using structured authoring tools like XML and DITA (Darwin Information Typing Architecture) for streamlined content development, and leveraging Web 2.0 technologies (e.g., blogs, wikis, forums) for collaborative technical communication. This prepares students for creating both printed and online content that is clear, translatable, and adaptable in technical contexts.

Course Objectives:

Upon successful completion of the course, students will be able to:

- Analyze and respond to rhetorical situations in technical writing, considering audience, organization, visual design, style, and production of documents relevant to technical fields.
- Produce professional-quality technical documents, both individually and collaboratively, incorporating planning, editing, and indexing for printed and online formats.
- Refine writing style to achieve clarity, concision, coherence, cohesion, and emphasis, while ensuring objectivity and ease of translation.
- Apply visual design principles and graphics to enhance document appeal and usability in technical applications like reports and manuals.
- Integrate modern tools and standards, such as XML-based structured authoring and DITA, to optimize content development processes.
- Utilize Web 2.0 technologies (e.g., blogs, wikis, forums) to facilitate interactive and collaborative technical communication.
- Practice native-like pronunciation and oral skills through audio-visual aids, enabling effective presentation of technical ideas.

Mode of Delivery:

The course will primarily use lectures and group discussions to foster interactive learning. Audio-visual aids, PowerPoint presentations, and multimedia tools (e.g., laptops, projectors, speakers) will be employed for effective teaching. Practice sessions will include listening to recorded instructions/descriptions and speaking activities, such as individual/group talks on assigned topics. To incorporate real-world elements, students will explore templates and structured authoring environments via hands-on demonstrations, emphasizing XML and DITA for content planning.

Course Contents:

Unit	Topics and Subtopics	Suggested Activities/Integration	Textbook/ Reference	Hours
Unit 1: So, What's a Technical Writer?	Knowledge of technology; Ignorance is bliss; Who treats the doctor and who documents for the writer?; Writing ability; Miss Thistlebottom was right.	Lecture on roles in Nepal's IT/data science sectors. Activity: Self-assessment of tech knowledge vs. writing skills. Integrate: Discuss free tools like Google Docs for entry-level planning.	*Technical Writing 101*, Chapter 1: "So, What's a Technical Writer?"	**6**
Unit 2: The Technical Writing Process	Overview of the writing process; Authoring with templates and structure; Template-based authoring; Structured authoring; Benefits for professional well-being.	Group discussion: Workflow for crop yield data report in Nepal. Activity: Draft using MS Word template. Integrate: Intro to XML/DITA via Notepad++.	*Technical Writing 101*, Chapter 2: "The Technical Writing Process"	**6**
Unit 3: Very Necessary Evils—Doc Plans and Outlines	What's a doc plan?; Creating outlines; Managing scope and timelines; Involving stakeholders.	Activity: Doc plan for hydropower data report. Group discussion: Outlines in local projects. Integrate: Google Sites for shared planning.	*Technical Writing 101*, Chapter 3: "Very Necessary Evils—Doc Plans and Outlines"	**6**
Unit 4: The Tech Writer's Toolbox	Content/text development tools for printed content; Graphics software; Rich media tools; Help/web authoring tools; File conversion utilities; Other software; Computers and ergonomics.	Hands-on: Explore free tools like Canva for graphics. Activity: Assemble a basic toolbox for data reports. Integrate: Ergonomics for Nepali workspaces.	*Technical Writing 101*, Chapter 4: "The Tech Writer's Toolbox"	**6**
Unit 5: Getting Information	Technical specifications; Benefits/drawbacks of specs; Prototypes/software under development; Legacy content.	Simulate interviews for rice production dataset. Activity: Organize notes into outline. Integrate: Nepali forums for data sourcing.	*Technical Writing 101*, Chapter 5: "Getting Information"	**6**
Unit 6: Visual Communication	Principles of effective visuals; Creating charts/diagrams; Integrating graphics into content.	Lecture on visuals for Nepali reports. Activity: Chart rainfall data with Canva. Integrate: Clarity for limited English audiences.	*Technical Writing 101*, Chapter 7: "Visual Communication"	**6**
Unit 7: Task-Oriented Writing (Procedures)	Writing procedures/instructions; User-centered content; Structuring for usability in step-by-step guides.	Activity: Instructions for open-source data tool in Nepal. Peer-review for clarity. Integrate: DITA	*Technical Writing 101*, Chapter 8: "Task-Oriented Writing"	**6**

Unit	Topics and Subtopics	Suggested Activities/Integration	Textbook/ Reference	Hours
		principles with free tools for modularity.		
Unit 8: Web 2.0 and Technical Communication	Impact of blogs/wikis/forums; Collaborative tools; Integrating Web 2.0 into workflows.	Activity: Wiki page on Google Sites for data science in Nepal. Lecture: DITA basics via Notepad++. Integrate: Free platforms for collaboration.	*Technical Writing 101*, Chapter 14: "Web 2.0 and Technical Communication"	**6**

Practice Sessions:

1. **Listening**: Exercises with recorded instructions (e.g., hydropower tutorials), followed by quizzes.
2. **Speaking**: Talks on "Data Science in Nepal's Agriculture"; peer feedback on pronunciation. Equipment: Laptop, projector, speakers.
3. **Practical Writing**: Hands-on with documents/manuals using free XML/DITA templates (e.g., Notepad++).

Reference Books:

1. Pringle, Alan S., and Sarah S. O'Keefe (2009). *Technical Writing 101: A Real-World Guide to Planning and Writing Technical Content*. 3rd ed., Scriptorium Publishing. (Details skills for printed/online content, XML/DITA for structured authoring, and Web 2.0 impacts like blogs/wikis/forums on technical communication.)
2. Alred, Gerald J., et al (2009). *Handbook of Technical Writing*. 9th ed., Bedford/St. Martin's.
3. Atkinson, Dawn, and Stacey Corbitt (2021). *Mindful Technical Writing: An Introduction to the Fundamentals*. Montana Technological University.
4. Laplante, Phillip A (2018). *Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals*. 2nd ed., CRC Press.

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