ATLAS SKILLTECH UNIVERSITY
uGDX School of Technology
Courses Offered
Core Courses, Elective Courses and Ability Enhancement Courses

Bachelor of Science (HONS)
(Artificial intelligence and Machine Learning)

4 Year Full Time Program

(Academic Year 2022-23)

PREAMBLE

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency, and excellence to the Higher Education System of the country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, governance, and other matters. The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC recently have led to overall improvement in the higher education system. However, due to a lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation, and grading systems. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fit the curriculum, syllabi, and teaching-learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for academia and employers to understand and infer the performance of the students graduating from different universities and colleges based on grades. The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce a uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in the grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

CHOICE BASED CREDIT SYSTEM

The CBCS provides an opportunity for the students to choose from the prescribed courses comprising core, elective/minor, or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education system in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing performance of the candidates. In order to bring uniformity in the evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

OUTLINE OF CHOICE BASED CREDIT SYSTEM

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a core course. The structure of course is defined under the following points

1.1.All the UG degree programs shall be of either six semesters or eight semesters of duration unless specified otherwise.

1.2. An academic year consists of two semesters: Odd Semester and an Even Semester.

1.3. A semester normally extends over 16 weeks (5 days a week) with 80 working days.

1.4. Every course offered may have three components: Lecture (L), Tutorial (T), and Practical (P). Tutorial session consists of participatory discussion/self-study/ desk work/ brief seminar presentations by students and other novel methods.

1.5. The credit pattern for a course (L: T:P) shall be decided by the respective Board of Studies (BoS).

1.6. Credit means the unit by which the coursework is measured. A one-hour session of Lecture or Tutorial per week for 16 weeks amounts to 1 credit.

1.7.Two hour session of Practicals per week for 16 weeks amounts to 1 credit per semester. The total duration of a semester is 20 weeks inclusive of the semester-end examination.

1.8.A course of 3 to 6 credits will be evaluated for 100 marks. A course with less than 3 credits will be evaluated for 50 marks. For any other approved course, the evaluation method shall be decided by the respective BoS.

2. ELECTIVE COURSE:

Elective Course is a course which can be chosen from a pool of courses. It may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill.

2.1.Discipline Specific Elective (DSE) is a course offered under the main discipline/subject of study or a Project/Dissertation.

2.2.Project/Dissertation is an elective course designed to acquire special/ advanced knowledge, such as supplement study/ support study to a project work. A student has to study such a course on his/her own with advisory support of a faculty member.

2.3.Generic Elective (GE) is an elective course chosen from an unrelated discipline/subject with an intention to seek exposure beyond discipline/subject.

3. Ability Enhancement Courses (AEC): Ability Enhancement Courses may be of two types: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC).

3.1.AECC courses are mandatory courses based upon the content that leads to knowledge enhancement viz., Environmental Science, Indian Constitution and English/ Modern Indian Languages (MIL) / Communication skills.

3.2. SEC courses are aimed at providing hands-on-training, competencies, skills, etc.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO 1	Apply theoretical concepts to real-world problems with strong and efficient computer science, machine learning and artificial intelligence skills with emphasis on data driven decision making.
PEO 2	Innovate and apply critical analysis in developing solutions, integrating model-based approaches, and using advanced tools and techniques for effective problem resolution.
PEO 3	Work in multidisciplinary environments and be responsive to the changing needs of the society and evaluate the environmental, societal, ethical, economic, health and safety implications of AI and ML applications.

PROGRAM OUTCOMES (PO)

PO	Program Outcome Skill	Program Outcomes (PO)
PO1	Domain Knowledge and STEM Skills	Demonstrate domain-specific knowledge coupled with a foundation in science, technology, engineering, and mathematics (STEM), enhancing the ability to apply computing skills in various professional domains.
PO2	Experimental Design and Data Analysis Skills	Demonstrate deep understanding of data science principles, thereby designing experiments and simulations, and analyzing and interpreting datasets for informed decision-making in various applications.
PO3	Development of Practical Solutions	Master programming languages and paradigms, showcasing the ability to develop efficient and scalable software solutions, considering realistic constraints such as economic, environmental, social, ethical, health and safety, and sustainability.
PO4	Individual and Collaborative Teamwork	Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings.
PO5	Problem Solving Skills	Develop strong problem-solving abilities, applying critical thinking, algorithmic thinking, and computational and model-based approaches to address complex challenges in diverse domains.
PO6	Ethics and Social Responsibility	Understand and apply ethical principles in computing, AI and ML, considering the societal impact of the work and making ethically informed decisions.
PO7	Effective Communication Skills	Learn to communicate complex technical concepts through powerful data visualizations, facilitating collaboration, and translating technical information for diverse audiences.
PO8	Environment and Sustainability	Understand and assess reliability, dependability and trustworthiness of AI and ML based systems and their impact in a global, economic, environmental and societal context.
PO9	Lifelong Learning	Recognize the need for, and have the ability to, engage in independent and lifelong learning and critical thinking in the

		face of rapidly involving technological landscape that is impacting all aspects of work and life across all disciplines.
PO10	Research and Development Skills	Be aware of contemporary issues facing industry and society, and engage in research and development activities, contributing to advancements in AI and ML through innovative projects and solutions.
PO11	Usage of Advanced Tools and Techniques	Apply latest AI and ML techniques, skills and tools to real-world scenarios, exhibiting competence in data engineering, developing models for data analysis, pattern recognition and decision making, and managing and deploying software solutions in multidisciplinary real-world environments.
PO12	Life Skills	Develop essential life skills, including adaptability, resilience, and a growth mindset for navigating dynamic professional environments and contributing meaningfully to society.

PROGRAM SPECIFIC OUTCOMES (PSO)

	Program Specific Outcomes (PSO)
PSO 1	Demonstrate mastery in foundational skills for informed decision-making, uncertainty assessment, designing algorithms to develop robust and reliable machine learning models.
PSO 2	Demonstrate ability to explore advanced topics in natural language processing, computer vision, and reinforcement learning for development of sophisticated AI addressing a wide range of tasks in diverse industries.
PSO 3	Demonstrate knowledge in effectively managing and processing large datasets, deploying scalable models in cloud environments, and ensuring seamless integration of AI solutions into practical applications with ethical, societal, economic, environmental, health and safety considerations.

B.Sc AI&ML (HONS)
FOUR-YEAR (8-SEMESTER)

Course Code	Course	Course Type	Periods			Evaluation Scheme				Credits
			L	T	P	MT	ET	CIA	Total	
Semester 1										
BSC MAT 101	Calculus - 1	Core	**3**			**20**	**40**	**40**	**100**	3
BSC CAP 101	Introduction to Computer Science and Programming using Python – 1	Core	**1**		**2**	**20**	**40**	**40**	**100**	3
BSC CAP 103	Essentials of R	Core	**1**		**2**	**20**	**40**	**40**	**100**	3
BSC MAT 103	Foundations of Probability and Statistics for Data Science – 1	Core	**3**			**20**	**40**	**40**	**100**	3
BSC CAP 105	The Art and Science of Storytelling with Data Visualizations	Core	**3**			**20**	**40**	**40**	**100**	2
BSC DSC 101	The World of Data Science	Core	**2**			**20**	**40**	**40**	**100**	2
BSC LS 01	Life Skills - Ethics & Values	VAC				**20**	**40**	**40**	**100**	2
BSC PE 101	Program Elective	AEC	2						100	2
	TOTAL									**20**

Semester 2										
BSC MAT 102	Calculus - 2	Core	**2**			**20**	**40**	**40**		2
BSC CAP 102	Introduction to Computer Science and Programming using Python – 2	Core	**1**		**2**	**20**	**40**	**40**		3
BSC MAT 104	Mathematics for Computer Science	Core	**3**			**20**	**40**	**40**		3
BSC DSC 102	Foundations of Probability and Statistics for Data Science – 2	Core	**1**		**2**	**20**	**40**	**40**		3
BSC MAT 106	Linear Algebra	Core	**3**			**20**	**40**	**40**		3
BSC DSC 104	Excel for Data Analytics	Core	**2**			**20**	**40**	**40**		2
AE	Atlas Elective	AEC	**2**							2
	TOTAL									**18**
Semester 3										
BSC ASC 201	Neuroscience and AI	Core	**3**			**20**	**40**	**40**		3
BSC DSC 201	Statistics and Probability in Decision Modeling - 1	Core	**1**		**2**	**20**	**40**	**40**		3

BSC CSE 201	Data Structures	Core	**3**			**20**	**40**	**40**		3
BSC MAT 201	Calculus - 3	Core	**3**			**20**	**40**	**40**		3
BSC CSE 203	SQL Programming	Core	**1**		**1**	**20**	**40**	**40**		2
BSC HUM 201	English for Business and Technical Communications	SEC	**2**			**20**	**40**	**40**		2
AE	Atlas Elective	AEC								2
	TOTAL									**18**
Semester 4										
BSC ASC 202	Quantum Physics	Core	**3**			**20**	**40**	**40**		3
BSC CAP 202	Introduction to Algorithms	Core	**3**			**20**	**40**	**40**		3
BSC DSC 202	Statistics and Probability in Decision Modeling - 2	Core	**1**		**1**	**20**	**40**	**40**		2
BSC CAP 204	Computer Organisation and Architecture	Core	**2**		**1**	**20**	**40**	**40**		3
BSC DSC 204	Applying ML to Big Data Using Hadoop and Spark Ecosystems	Core	**1**		**2**	**20**	**40**	**40**		3

BSC MAT 202	Calculus - 4	Core	**2**			**20**	**40**	**40**		2
BSC LS 02	Communication, Ethical and IP Challenges for Analytics Professionals	VAC	**2**			**20**	**40**	**40**		2
	ATLAS Elective	AEC								2
	TOTAL									**20**
Semester 5										
	Optimization and Decision Analysis	Core	**1**		**2**	**20**	**40**	**40**		3
	Methods and Algorithms in Machine Learning – 1	Core	**3**			**20**	**40**	**40**		3
	Research Methodology	Core	**3**			**20**	**40**	**40**		3
	Neural Networks on Structured Data	Core	**1**		**2**	**20**	**40**	**40**		3
	Data Engineering Services on Cloud	Core	**1**		**1**	**20**	**40**	**40**		2
	Computer Networks	Core	**1**		**1**	**20**	**40**	**40**		2
	Surviving in the Consulting World (life Skill)	VAC	**2**			**20**	**40**	**40**		2
	Minor Project	PRJ								2
	Atlas Elective	AEC								3
	TOTAL									**23**

Semester 6										
	Methods and Algorithms in Machine Learning - 2	Core	**1**		**1**	**20**	**40**	**40**		2
	Essential Chemistry for Data Science	Core	**3**			**20**	**40**	**40**		3
	DevOps and MLOps	Core	**2**		**1**	**20**	**40**	**40**		3
	Introduction to Deep Neural Networks	Core	**2**		**1**	**20**	**40**	**40**		3
	Methods and Algorithms in Machine Learning - 3	Core	**1**		**1**	**20**	**40**	**40**		2
	Design Thinking for Data Scientists	SEC	**2**			**20**	**40**	**40**		2
	Atlas Elective	AEC								2
	Minor Project	PRJ								2
										19
Semester 7										
	Text Mining and Natural Language Processing Using Deep Learning - 1	Core	**1**		**1**	**20**	**40**	**40**		2
	Text Mining and Natural Language Processing Using Deep Learning - 2	Core	**1**		**1**	**20**	**40**	**40**		2
	Project Work	PRJ								6
	Artificial Intelligence in Finance	Core	**1**		**2**	**20**	**40**	**40**		3

	Artificial Intelligence in Supply Chain	Core	**1**		**2**	**20**	**40**	**40**		3
	Disruptive Digital Technologies and their Real-World Applications - 1	SEC	**2**			**20**	**40**	**40**		2
	Atlas Elective	AEC								2
	TOTAL									**20**
Semester 8										
	Computer Vision - 1	Core	**1**		**1**	**20**	**40**	**40**		2
	Computer Vision - 2	Core	**1**		**1**	**20**	**40**	**40**		2
	Internship	PRJ				**20**	**40**	**40**		6
	Artificial Intelligence in Retail	Core	**1**		**2**	**20**	**40**	**40**		3
	Artificial Intelligence in Healthcare	Core	**1**		**2**	**20**	**40**	**40**		3
	Disruptive Digital Technologies and their Real-World Applications - 2	SEC	**2**			**20**	**40**	**40**		2
	Atlas Elective	AEC								2
	Life Skill									2
	TOTAL									**22**

SEMESTER 1

B.SC (HONS) FIRST YEAR

L	T	P
1		1

COURSE NAME: CALCULUS – 1 **CONTACT HOURS: 3**
COURSE CREDIT HOURS: 3 **COURSE CODE: BSC MAT 101**

COURSE DESCRIPTION:

This course is intended to develop practical skills in differential calculus. Calculus plays an important role in science, engineering, computer science, data engineering, artificial intelligence, economics, finance, and many other fields. Topics covered in this course include review of functions and trigonometric functions, limits, rates of change, differentiation, the mean value theorem, and applications of derivatives.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

This course is the first course in a four-course calculus sequence. Students who successfully complete this course may continue into "Calculus - 2", which is taught in the second semester. The objectives of this course are the following: to enable students to become a competent user of differential calculus, to enable them to develop the ability to write well-organized, coherent solutions to problems, to enable them to understand the concept of derivative as representing rate of change and slope, and to position students so that they can excel in subjects with calculus components

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

1. Evaluate limits and determine continuity properties of functions (CO1)
2. Calculate derivatives using a variety of methods (CO2)
3. Analyze the connection between derivatives and tangent lines, and find the equation of the tangent line to a graph at a given point (CO3)
4. Interpret derivatives across several fields of physical sciences and engineering (CO4)
5. Solve maximum and minimum problems using differentiation (CO5)
6. Apply methods of calculus to curve sketching (CO6)

LEARNING RESOURCES

Required Resources

- George B. Thomas, Jr. (with revisions by Joel Hass, Christopher Heil and Maurice D. Weir), “Thomas’ Calculus”, 14th Edition, Pearson, 2018.

Recommended Resources:

- n/a

COURSE CONTENT

Sr.No	Modules/ Units
1	**Functions**
2	**Limits and continuity**
	Rates of change and tangent lines to curves Limit of a function and limit laws The precise definition of a limit One-sided limits Continuity Limits involving infinity
3	**Derivatives**
	Tangent lines and the derivative at a point The derivative of a function Differentiation rules The derivative as a rate of change Derivatives of trigonometric functions The chain rule Implicit differentiation Related rates Linearization and differentials
4	**Applications of derivatives**
	Extreme values of functions on closed intervals The mean value theorem

	Monotonic functions and the first derivative test Concavity and curve sketching Applied optimization Newton's method Antiderivatives

L	T	P
1		2

COURSE NAME: INTRODUCTION TO COMPUTER SCIENCE AND PROGRAMMING USING PYTHON – 1 **CONTACT HOURS: 5**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC CAP 101**

COURSE DESCRIPTION:
This course is an introduction to computer programming. No prior programming experience is assumed. Students will learn to design, write, and debug computer programs in Python. Topics covered include variables and data types, tuples, lists, dictionaries, input and output methods, control structures, functions and testing and debugging. This course will introduce students to computational approaches to problem solving using Python. Modern software engineering principles, especially modularity, will also be emphasized. By the end of the course, students will have learnt to write their own functions and programs in Python.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

Computational thinking is the process of analyzing a problem, and then designing and expressing its solution in such a way that a computer can effectively solve the problem. Computational thinking includes a number of characteristics, such as breaking a problem into small and repetitive ordered steps, logically ordering and analyzing data, and creating solutions that can be effectively implemented as programs running on a computer.
The aim of this course is hence to take students with no prior experience of thinking in a computational manner to a point where they can derive simple algorithms and code the programs to solve some basic problems in their chosen domains. Students will also learn about Python variables and expressions, looping mechanisms, functions, lists, and dictionaries.

COURSE OUTCOMES (CO'S)
After completion of the course, student should be able to:

1. Apply basic concepts of computational thinking, including sequential logic, abstractions, conceptualization and problem-solving (CO1)
2. Develop computer solutions to problems of low-to-moderate complexity (CO2)
3. Implement solutions using suitable data types and constructs in Python (CO3)
4. Model real-life problems as computational problems (CO4)

LEARNING RESOURCES

Required Resources

- John Guttag, "Introduction to Computation and Programming Using Python: With Application to Understanding Data," Second Edition, PHI, 2016.

Recommended Resources:

- Donald Knuth, "The art of computer programming", Volumes 1, Fundamental Algorithms, Addison-Wesley, 1968.
- Mark Lutz, "Learning Python", 5th Edition, O'Reilley, 2013.

Recommended Resources:

- N/A

COURSE CONTENT

Sr.No	Modules/ Units
1	**Introduction to Machines and Languages**
2	**Introduction to Python**
	Objects, expressions Numerical types, variables and assignment Python IDE's Branching programs Strings and input
3	**Some simple numerical programs**
	Exhaustive enumeration For loops Approximate solutions Bisection search Floats
4	**Functions, scoping, and abstraction**
	Functions and Scoping Specifications Recursion Global Variables Modules Files
5	**Structured types, mutability, and higher-order functions**
	Tuples Ranges Lists and mutability Functions as objects Strings, tuples, ranges, and lists Dictionaries

L	T	P
3		

COURSE NAME: ESSENTIALS OF R **COURSE CONTACT HOURS:3**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC CAP 103**

COURSE DESCRIPTION:

This course aims to make students understand the concepts of the R programming language without any prior knowledge on any programming language. The topics in this course include the Introduction to R programming language and using R studio IDE, variables, data types, vectors, matrices, data frames, functions, scripting loops, conditional statements, loading and

working with datasets in various formats, summarizing data, using the family of apply functions, develop code to prepare data for analysis and basics of data visualization with R. By the end of this course students will be able to write their code with logic and analyse data and visualize data effortlessly in R programming language.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

- Be able to use R Programming to perform statistical analysis.

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

1. Gaining familiarity on R programming language and R studio. Implementing simple Math calculations in R.
2. Understanding the data types and data structures in R such as vectors, matrices, data frames, lists and working with the objects of data structures.
3. Understanding how to implement the programming structures such as custom functions, apply functions, control statements and loops.
4. Able to load data various formats, understanding data with descriptive statistics, data transformations and prepare data for analytics.
5. Understanding the value of storytelling with data, plotting different data types with uni-variate and multi-variate charts and draw insights form charts with ggplot library in R.

LEARNING RESOURCES

Required Resources

1. https://www.w3schools.com/r/
2. https://www.statmethods.net/r-tutorial/index.html

Recommended Resources:

Hadley Wickham, Garrett Grolemund "R for Data Science", "O'Reilly Media, Inc.",

COURSE CONTENT

Sr.No	Modules/ Units
1	**Introduction to the World of R Programming**

	Installation and setting-up computer History and Context Executing Simple R Programs Simple Mathematic operations
2	**Atomic Data Type**
	Relational and Logical operators in R
3	**Getting familiar with R and working with objects**
	Vectors, matrix, Array, dataframes
4	**Programming Structures**
	Loops Conditional Statements
5	**Descriptive statistics**
	Applying basic descriptive statistics on the data
6	**Story-telling and Data Visualization**
	Visualizing data using Bar chart, Line chart, Histogram, Scatter plot, Pie chart using R base and ggplot packages

L	T	P
3		

COURSE NAME: FOUNDATIONS OF PROBABILITY AND STATISTICS FOR DATA SCIENCE – 1 **CONTACT HOURS: 2**
COURSE CREDIT HOURS: 2 **COURSE CODE: BSC MAT 103**

COURSE DESCRIPTION:

Understand the foundations of probability and its relationship to statistics and data science. Learn what it means to calculate a probability, independent and dependent outcomes, and conditional events. Study discrete and continuous random variables and see how this fits with data collection. And, end the course with Gaussian (normal) random variables and the Central Limit Theorem and understand its fundamental importance for all of statistics and data science.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of the course are as follows:

- Explain why probability is important to statistics and data science.
- See the relationship between conditional and independent events in a statistical experiment.

- Calculate the expectation and variance of several random variables and develop some intuition

COURSE OUTCOMES (CO'S)

After completion of the course, students should be able to:

1. Be able to explain Basic Statistical Terminology like Population, Sample, Parameter, Statistic etc and appreciate the science of statistics
2. Be able to understand the Measures of Central Tendencies and Dispersion
3. Be able to understand Probability Theory, Random Variable, Events, Sample Sub-Space and its Properties
4. Be able to understand Probability Types and various rules of Calculating them
5. Be able to understand Sampling Distribution

LEARNING RESOURCES

Required Resources

Michael J. Evans and Jeffrey S. Rosenthal, "Probability and Statistics The Science of Uncertainty Second Edition" University of Toronto, https://www.utstat.toronto.edu/mikevans/jeffrosenthal/book.pdf

Recommended Resources:

Christian Heumann & Michael Schomaker Shalabh, "Introduction to Statistics and Data Analysis", Springer

Charles M. Grinstead, J. Laurie Snell "Introduction to Probability", American Mathematical Society

COURSE CONTENT

Sr.No	Modules/ Units
1	**Intro to Statistical Methods**
2	**Central Tendencies**

	Mean, Median, Mode
3	Measures of Dispersion
	Range, mean deviation, Standard deviation
4	Probability
	Intro to Probability Difference between Probability and statistics Types of Probability Conditional Probability and Bayes Theorem
5	Random Variable
	Density Function PDF CDF
6	Discrete Distribution
	Binomial Poisson
7	Continuous Distribution
	Geometric Normal

L	T	P
2		

COURSE NAME: ART AND SCIENCE OF STORY **COURSE CONTACT HOURS: 2**
COURSE CREDIT HOURS: 2 **COURSE CODE: BSC CAP 105**

COURSE DESCRIPTION:

This course aims to make students understand the concepts of the R programming language without any prior knowledge on any programming language. The topics in this course include the Introduction to R programming language and using R studio IDE, variables, data types, vectors, matrices, data frames, functions, scripting loops, conditional statements, loading and working with datasets in various formats, summarizing data, using the family of apply functions, develop code to prepare data for analysis and basics of data visualization with R. By the end of this course students will be able to write their code with logic and analyse data and visualize data effortlessly in R programming language.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of this course are:

- Be able to use understand the need for and importance of Visualisation and storytelling in data science
- Use Tableau/R/Python to Visualise and infer the Data.

COURSE OUTCOMES (COS)

After completion of the course, the student should be able to:

1. Be able to understand the need for and importance of data visualizations.
2. Be able to understand and identify appropriate plots for given scenarios and data.
3. Be able to choose appropriate attributes and aesthetics for the plot.
4. Be able to prepare the data appropriately to answer the questions to have a qualitative analysis.
5. Be able to map the variable to a cue (such a x, y, colour etc)
6. Be able to use various tools such as Tableau/R/Python to Visualise the data.
7. Be able to understand and implement various data source connections.

LEARNING RESOURCES

Required Resources

1. https://www.w3schools.com/r/
2. https://www.statmethods.net/r-tutorial/index.html
3. https://www.javatpoint.com/r-data-visualization
4. https://www.geeksforgeeks.org/data-visualization-with-python/
5. https://www.tableau.com/learn/articles/data-visualization

Recommended Resources:

Hadley Wickham, Garrett Grolemund “R for Data Science”, "O'Reilly Media, Inc.",

COURSE CONTENT

Sr.No	Modules/ Units
1	Introduction to the Art and Science of Data Visualisation using Visualisation
	Installations and setting-up computer History and Context Understanding Basic Plots

2	Visualisation using Tableau
	Introduction to Tableau Data Connection and basic plotting Data Analysis Table Calculations
3	**Creating Dashboards using Tableau**
	Developing Dashboards and Buttons
4	**Visualisation using Python**
	Use libraries such as Pandas, NumPy, Matplotlib to read data frames and plot
5	**Advanced Visualisation using R**
	Use ggplot library to plot in R
6	**Dashboard using R**
	Use Shiny Library to create Dashboard in R

L	T	P
2		

COURSE NAME: THE WORLD OF DATA SCIENCE COURSE CONTACT HOURS: 2
COURSE CREDIT HOURS: 2 COURSE CODE: BSC DSC 101

COURSE DESCRIPTION:

This comprehensive course is designed to kindle students' interest in field of data science. The course is designed to be interactive. The instructor will introduce the basic theoretical concepts in data science. Students will interact with the instructor and field experts on state of the art capabilities of artificial intelligence.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

COURSE OBJECTIVES

- What constitutes data?
- Data sciences and other science
- How can a statistical model explain real world problems?
- Applications of data science in different fields.

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. Be able to Understand Data and its Characteristics.
2. Be able to Differentiate Data sciences and other sciences.
3. Be able to use Statistics to explain Real world problems.
4. Be able to apply data science in different fields.

5.

LEARNING RESOURCES

Required Resources

Class Notes

Recommended Resources:

COURSE CONTENT

Sr.No	Modules/ Units
1	Understand Data and its Characteristics
2	Data sciences and other science
3	Use Statistics to explain Real world problems
4	Applications of data science in different fields
	Industry 4.0 Finance Credit Risk Supply Chain Medical Chemical

SEMESTER 2

L	T	P
3		

COURSE NAME: CALCULUS – 2 **COURSE CONTACT HOURS: 3**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC MAT 102**

COURSE DESCRIPTION:

This course is intended to develop practical skills in integral calculus. Calculus plays an important role in science, engineering, computer science, data engineering, artificial intelligence, economics, finance, and many other fields. Topics covered in this course include review of application of derivatives, definite and indefinite integrals, and applications of definite integrals.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

This course is the second course in a four-course calculus sequence. Students who successfully complete this course may continue into "Calculus - 3", which is taught in the second semester. The objectives of this course are the following: to enable students to become a competent user of integral calculus, to enable them to develop the ability to write well-organized, coherent solutions to problems, to enable them to understand the concept of integration, its applications and to position students so that they can excel in subjects with calculus components.

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

1. Become a competent user of differential and integral calculus. (CO1)
2. Develop ability to write well-organized, coherent solutions to problems. (CO2)
3. Position students so that they can excel in subjects with calculus components. (CO3)
4. Understand and appreciate the fundamental theorem of calculus. (CO4)
5. Use integrals to solve problems in a variety of engineering and non-engineering disciplines (CO5)
6. Understand transcendental functions.

LEARNING RESOURCES

Required Resources

• George B. Thomas, Jr. (with revisions by Joel Hass, Christopher Heil and Maurice D. Weir), "Thomas' Calculus", 14th Edition, Pearson, 2018.

Recommended Resources:

• n/a

COURSE CONTENT

Sr.No	Modules/Unit
1.	**Integrals**
	Area and Estimating with Finite Sums Sigma Notation and Limits of Finite Sum The Definite Integral The Fundamental Theorem of Calculus Indefinite Integrals and the Substitution Method Definite Integral Substitutions and the Area Between Curves
2.	**Application of Definite Integrals**
	Volumes Using Cross-Sections Volumes Using Cylindrical Shells Arc Length Areas of Surfaces of Revolution Work and Fluid Forces Moments and Centers of Mass
3	**Transcendental Functions**

	Inverse Functions and Their Derivatives Natural Logarithms Exponential Functions Exponential Change and Separable Differential Equations Indeterminate Forms and L'Hôpital's Rule Inverse Trigonometric Functions Hyperbolic Functions Relative Rates of Growth

L	T	P
1		4

COURSE NAME: INTRODUCTION TO COMPUTER SCIENCE AND PROGRAMMING USING PYTHON - 2 **COURSE CONTACT HOURS:45**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC CAP 102**

COURSE DESCRIPTION:

Computational thinking is the process of analysing a problem, and then designing and expressing its solution in such a way that a computer can effectively solve the problem. Computational thinking includes a number of characteristics, such as breaking a problem into small and repetitive ordered steps, logically ordering and analyzing data, and creating solutions that can be effectively implemented as programs running on a computer.

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COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The aim of this course is to take students with basic programming skills to a point where they can solve more complex problems, taking program efficiency into consideration. Besides learning to debug programs, students will also learn about object-oriented programming and some simple algorithms and data structures

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

1. CO1: Apply basic concepts of computational thinking, including sequential logic, abstractions, conceptualization and problem-solving

2. CO2: Apply principles of debugging and testing to ensure the reliability and correctness of implemented solutions.
3. CO2: Develop computer solutions to problems of moderate complexity
4. CO3: Implement solutions using suitable classes and data structures and algorithms in Python
5. CO5: Analyze the time and space complexity of the algorithms, identify potential bottlenecks, and optimize the solutions for improved performance.
6. CO4: Model real-life problems as computational problems

LEARNING RESOURCES

Required Resources

- John Guttag, "Introduction to Computation and Programming Using Python: With Application to Understanding Data," Second Edition, PHI, 2016.

Recommended Resources:

- Donald Knuth, "The art of computer programming", Volumes 1, Fundamental Algorithms, Addison-Wesley, 1968.
- Mark Lutz, "Learning Python", 5th Edition, O'Reilley, 2013.

COURSE CONTENT

Sr.No	Modules/ Units
1	Testing and debugging
	Testing Debugging
2	Exceptions and assertions
	Handling exceptions Exceptions as a control flow mechanism Assertions
3	Classes and object-oriented programming
	Abstract data types and classes Inheritance Encapsulation and information hiding
4	A simplistic introduction to algorithmic complexity

	Thinking about computational complexity Asymptotic notation Some important complexity classes
5	Some simple algorithms and data structures
	Search algorithms Sorting algorithms

L	T	P
1	2	

COURSE NAME: MATHEMATICS FOR COMPUTER SCIENCE COURSE

CONTACT HOURS: 45

COURSE CREDIT HOURS: 3

COURSE CODE: BSC MAT 104

COURSE DESCRIPTION:

This course offers an introduction to discrete mathematics oriented toward computer science and engineering. Topics covered include the following: logic and proofs, sets and functions, number theory, proof by induction, counting techniques, recurrences, relations, and graphs.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

After completing this course, students will be able to explain and apply basic methods of discrete (noncontinuous) mathematics in computer science. These methods will be used in subsequent courses in data structures, design and analysis of algorithms, computation, software engineering and computer systems.

COURSE OUTCOMES (CO'S)

After completion of the course, students should be able to:

1. Communicate logically rigorously, prove mathematical statements with logical rigor, and identify fallacious reasoning (CO1)
2. Use logical notation to define and reason about fundamental mathematical concepts such as sets and functions (CO2)
3. Prove elementary properties of modular arithmetic and explain their applications in computer science, for example, in cryptography and hashing algorithms (CO3)
4. Synthesize induction hypotheses and simple induction proofs (CO4)

5. Calculate numbers of possible outcomes of elementary combinatorial processes such as permutations and combinations (CO5)
6. Derive closed-form and asymptotic expressions from series and recurrences for growth rates of processes (CO6)
7. Prove properties of relations and graphs and model real-world problems using relations and graphs (CO7)

LEARNING RESOURCES

Required Resources

- Kenneth Rosen, "Discrete Mathematics and its Applications," Seventh Edition, McGraw Hill, 2012.

Recommended Resources:

- "Mathematics for Computer Science", MIT Open Courseware, 6.042J, Fall 2010. Course notes at https://ocw.mit.edu/courses/6-042j-mathematics-for-computer-science-fall-2010/pages/readings/

COURSE CONTENT

Sr.No	Modules/ Units
1	Foundations: logic and proofs
	Proposition logic and equivalences Predicates and quantifiers Rules of inference Introduction to proofs
2	Sets, functions, number theory, induction
	Sets and set operations Functions Divisibility and modular arithmetic Primes and greatest common divisors Induction and strong induction
3	Counting
	Basics of counting Pigeonhole principle Permutations and combinations Applications of recurrence relations

	Solving linear recurrence relations Generating functions
4	Relations
	Relations and their properties Representing relations Equivalence relations Partial orderings
5	Graphs
	Graphs and graph models Graph terminology and special types of graphs Representing graphs and graph isomorphism Connectivity Euler and hamilton paths Planar graphs Graph coloring

L	T	P
2	2	

COURSE NAME: FOUNDATIONS OF PROBABILITY AND STATISTICS FOR DATA SCIENCE 2 **CONTACT HOURS: 45**

COMPUTER SCIENCE COURSE

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC DSC 102**

Course Description: Understand the foundations of probability and its relationship to statistics and data science. Learn what it means to calculate a probability, independent and dependent outcomes, and conditional events. Study discrete and continuous random variables and see how this fits with data collection. And, end the course with Gaussian (normal) random variables and the Central Limit Theorem and understand its fundamental importance for all of statistics and data science.

Course Aims, Learning Objectives, and Graduate Attributes

Course Objectives

- Explain why probability is important to statistics and data science.
- See the relationship between conditional and independent events in a statistical experiment.
- Calculate the expectation and variance of several random variables and develop some intuition.

Course Outcomes

After completion of the course, you should be able:

1. To be able to understand Law of large numbers and Central Limit Theorem.
2. To be able to understand point and interval estimation,
3. To be able to formulate and conduct a hypothesis test like
4. To be able to understand

Learning Resources

Required Resources

Michael J. Evans and Jeffrey S. Rosenthal, “Probability and Statistics The Science of Uncertainty Second Edition” University of Toronto, https://www.utstat.toronto.edu/mikevans/jeffrosenthal/book.pdf

Recommended Resources:

Christian Heumann & Michael Schomaker Shalabh, “Introduction to Statistics and Data Analysis”, Springer

Charles M. Grinstead, J. Laurie Snell “Introduction to Probability”, American Mathematical Society

Teaching & Learning Activities

Course Content

Sr.No	Modules/ Units
1	Central Limit Theorem
2	Hypothesis Testing
3	Confidence Intervals
4	T-test
5	Chi-square
6	F-test

7	Anova

L	T	P
1	2	

COURSE NAME: LINEAR ALGEBRA **COURSE CONTACT HOURS: 3**
COURSE CREDIT HOURS: 45 **COURSE CODE: BSC MAT 106**

COURSE DESCRIPTION:

This course is a basic introduction to linear algebra and its applications. Linear algebra plays an important role in science, engineering, computer science, data engineering, artificial intelligence, economics, finance, and many other fields. Topics covered in this course include system of linear equations, matrix representation of data, matrices as coordinate systems, determinants, and vector spaces.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of this course are the following: to enable students to become a competent user of linear algebra, to enable them to develop the ability to write well-organized, coherent solutions to problems, understand its applications and to position students so that they can excel in subjects with linear algebra components

COURSE OUTCOMES (COS)

After completion of the course, the student should be able to:

1. Appreciate the utility of linear algebra across various domains like economics, science, and engineering. (CO1)
2. Develop ability to write well-organized, coherent solutions to problems. (CO2)
3. Solve linear system of equations (CO3)
4. Manipulate matrices to solve linear equations. (CO4)
5. Understand vector spaces. (CO5)

LEARNING RESOURCES

Required Resources:

• Linear Algebra and its applications David C Lay (4th Edition)-Addison Wesley _ Pearson (2011)

Recommended Resources:

• n/a

COURSE CONTENT

Sr. No	Modules/ Units
1	**Linear Equations in Linear Algebra**
	System of Linear Equations
	Row Reduction and Echelon Forms
	Vector Equations
	Matrix Equations
	Solution sets of Linear System
	Linear Independence
	Introduction to Linear Transformation
2	**Matrix Algebra**
	Matrix operations
	Inverse of matrix
	Partitioned matrices
	Matrix Factorizations
	Sub Spaces
	Dimensions and Rank
3	**Determinants**

	Introduction to Determinants
	Cramer’s Rule
4	**Vector Spaces**
	Vector Spaces and sub spaces
	Linearly independent sets – bases
	Dimensions and Rank, change of bases
	Markov chains

L	**T**	**P**
1	**2**	

COURSE NAME: Excel for Data Analytics **COURSE CONTACT HOURS: 5**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC DSC 104**

COURSE DESCRIPTION:

The objective of this course is to develop an understanding on using Microsoft Excel as an application for doing business analytics right from reading and representing data to getting visual insights, data manipulation and filtering techniques, and coming up with meaningful and actionable insights that help businesses make data-driven decisions.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

- Explain why probability is important to statistics and data science.
- See the relationship between conditional and independent events in a statistical experiment.
- Calculate the expectation and variance of several random variables and develop some intuition.

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

- To be able to understand the tools and working functionalities of Microsoft Excel for basic data manipulation.
- To be able to understand advanced data wrangling and filtering methods to do data mining and gain meaningful insights.
- To be able to visualize data and get meaningful insights.
- To be able to understand the impact of certain features on a target outcome by doing basic regression analyses.

LEARNING RESOURCES

Required Resources

Business Analytics: Data Analysis & Decision Making, 6E
Using Excel for Business Analysis: A Guide to Financial Modelling Fundamentals, Danielle Stein Fairhurst

Recommended Resources:

https://support.microsoft.com/en-us/excel
https://support.microsoft.com/en-us/office/excel-video-training-9bc05390-e94c-46af-a5b3-d7c22f6990bb
LinkedIn Learning material for 'Excel for Business Analysts', by Michael McDonald

COURSE CONTENT

Sr.No	Modules/ Units
1	Introduction to the tool, various options and functionalities. Introduction to Business Analytics and the importance of Excel for Business Analytics Representation of data types, formats and different ways of reading data into Excel and reviewing it
2	Understanding different data types in Excel Type conversion Arithmetic and statistical operations using in-built functions Writing Formulae using in-built functions
3	Data cleansing methods Understanding different options in copying-pasting Formatting, Conditional Formatting Deriving new features by writing formulae String Manipulations Date Manipulations Cross-sheet functionalities Exploring options from all sections of menu bar Data standardization
4	Writing custom functions Filtering using functions, custom functions, subtotals etc Data filtering and aggregations using Pivot tables, VLOOKUP etc
5	Understanding when to plot what charts Plotting charts in Excel Plotting charts from Pivot tables Creating dashboards and coming up with meaningful insights

SECOND YEAR
SEMESTER 3

L	T	P
2		2

COURSE NAME: NEUROSCIENCE AND AI **CONTACT HOURS: 3**

COURSE CREDIT HOURS: 2 COURSE CODE: BSC ASC 201

COURSE DESCRIPTION:

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The course is aimed to be act as an introduction to behavioural neuroscience.

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

Explain the structure of a cell and contrast it with a neuron (CO1)

1. Describe the basic structure of sensory systems (CO2)
2. Describe biological motor systems and discuss its adaptation for robotic systems (CO3)
3. Explain the biological basis of emotions and behaviour (CO4)
4. Review neurological disorders and compare the biological basis of these (CO5)
5. Describe how biological systems learn, store and retrieve information from the brain. (CO6)
6. Contrast the salient features of biological and algorithm based neural networks. (CO7)

LEARNING RESOURCES

Required Resources

Introduction to Neuroscience (IoN):
https://open.umn.edu/opentextbooks/textbooks/introduction-to-neuroscience-2022
Valerie Hedges, East Lansing, MI
Copyright Year: 2022
ISBN 13: 9781626101227
Publisher: Michigan State University

Foundations of Neuroscience (FoN):
https://open.umn.edu/opentextbooks/textbooks/foundations-of-neuroscience
Casey Henley, Michigan State University
Copyright Year: 2021
ISBN 13: 9781626101098
Publisher: Michigan State University

COURSE CONTENT

Sr.No	Modules/ Units
1	Cells and Neuron
	Introduction to biological systems Neuron structure and function Synapses Neuronal communication
2	Organization of nervous system
	Anatomical terminology Brain structure Imaging the brain Generating data for AI from brain
3	Sensory systems
	Visual system Auditory system Attention
4	Motor system
	Motor control and proprioception Spinal reflexes Planning and execution of movement The robotics link in motor control
5	Behavior
	Pain and emotion Motivated behavior Social bonding Sleep, emotion and stress
6	Neuro-degenerative disorders
	Autism spectrum disorders Schizophrenia Alzeimer’s

	Developmental disorders
7	Artificial Brains
	What is it and where are we? Brain simulation

L	T	P
2		2

COURSE NAME: STATISTICS AND PROBABILITY IN DECISION MODELING – 1 **COURSE CONTACT HOURS:3**

COURSE CREDIT HOURS: 3 **COURSE CODE : BSC DSC 201**

COURSE DESCRIPTION:

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The course aims to prepare students to use statistical decision making to make informed decisions in a variety of real-world contexts.

COURSE OUTCOMES (CO'S)

After completion of the course, student should be able to:

1. Explain the concepts of linear regression, logistic regression, and Naïve Bayes classification. (CO1)
2. Describe the assumptions of the models and how to identify and address violations of these assumptions. (CO2)
3. Build and interpret linear regression, logistic regression, and Naïve Bayes classification models using Python. (CO3)
4. Evaluate and select the best model for a given problem. (CO4)
5. Apply statistical decision modelling techniques to real-world problems. (CO5)

LEARNING RESOURCES

Lecture notes and Jupyter Notebooks

Recommended Resources:

1. Statistical Methods for Data Science by David Smith
2. The Elements of Statistical Learning: Data Mining, Inference, and Prediction by Trevor Hastie, Robert Tibshirani, and Jerome Friedman
3. Python for Data Analysis by Wes McKinney
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurélien Géron
5. Logistic Regression Models for Medical Research: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7785709/ by Hosmer, David W. and Stanley Lemeshow
6. Applied Logistic Regression: Analysis and Interpretation: https://methods.sagepub.com/book/applied-logistic-regression-analysis by Scott Menard

COURSE CONTENT

Sr.No	Modules/ Units
1	**Introduction to Statistical Decision Making**

	What is statistical decision making? Why is statistical decision making important? Different types of statistical models Applications of statistical decision making
2	**Linear Regression**
	What is linear regression? Ordinary Least Squares (OLS) regression Assumptions of linear regression Model evaluation and selection Residual analysis Handling categorical independent variables Stepwise regression AIC and model selection Multicollinearity and VIF Error metrics for performance evaluation Building linear regression models in Python
3	**Logistic Regression**

	What is logistic regression? Sigmoid function, odds, and the logit function Logistic model equation Difference between probability and likelihood Maximum Likelihood Estimate (MLE) approach Gradient Descent algorithm Interpreting logistic regression model output Null and residual deviance Identifying statistically significant attributes Evaluating classification models using testing/validation data Interpreting confusion matrices Computing precision, recall, specificity, accuracy, and F1 score ROC curves and AUC in model evaluation and selection Lift and Gains Charts Building logistic regression models in Python
4	**Naïve Bayes Classification**
	What is Naïve Bayes classification? Naïve assumption Marginal, conditional probabilities, and posterior probabilities A-priori and conditional probabilities Implementing the Naïve Bayes classification algorithm in Python
5	**Real-World Applications of Statistical Decision Making**
	Case studies in linear regression, logistic regression, and Naïve Bayes classification Ethical considerations in statistical decision modelling

L	T	P
2		2

COURSE NAME: DATA STRUCTURES **COURSE CONTACT HOURS:** 3
COURSE CREDIT HOURS: 3 **COURSE CODE:** BSC CSE 201

COURSE DESCRIPTION:

This course introduces the common data structures used to solve computational problems. The relationship between algorithms and programming is emphasized, and

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES
The objectives of the course are as follows:

COURSE OUTCOMES (CO'S)
After completion of the course, students should be able to:

1. Analyze the runtime performance of algorithms in terms of Big O, Big Omega, and Big Theta notation. (CO1)
2. Write programs that make good use of stacks, queues, linked lists, trees, graphs, and hash tables. (CO2)
3. Design or select an appropriate data structure for a particular problem. (CO3)

LEARNING RESOURCES

Required Resources

- A. V. Aho, J. E. Hopcroft, and J. E. Ullman, ``Data Structures and Algorithms", Pearson India, 2002. [AHU]
- T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, ``Introduction to Algorithms", Third edition, Publisher: MIT Press, 2009. [CLRS]

Recommended Resources:

- T. Roughgarden, ``Algorithms Illuminated, Part 1: The Basics", 2017.
- S. Dasgupta, C. Papadimitriou and U. Vazirani, ``Algorithms", Tata McGraw-Hill, 2008.

- D. Knuth, ``The Art of Computer Programming, Volume 1: Fundamental Algorithms", Third Edition, Addison-Wesley, 1997.
- D. Knuth, ``The Art of Computer Programming, Volume 3: Sorting and Searching", Second Edition, Addison-Wesley, 1998.
- A. Bell, E. Grimson, and J. Guttag. 6.0001, ``Introduction to Computer Science and Programming in Python", Fall 2016. MIT OpenCourseWare, https://ocw.mit.edu
- J. Guttag, ``Introduction to Computation and Programming Using Python with Application to Understanding Data", Second Edition, MIT Press, 2016.
- J. Leskovec, A. Rajaraman, and J. Ullman, ``Mining of Massive Datasets", Third Edition, 2019. Freely downloadable from mmds.org.

Course Content

Sr.No	Modules/ Units
1	Preliminaries: Analysis of Algorithms
	Time complexity and insertion sort Analysis of algorithms Asymptotic notation, proof of correctness Merge sort, analysis of merge sort Master theorem
2	Data Structures
	Array implementation of lists Linked lists Stacks and queues Trees Heaps, Building a maxheap Heapsort and priority queues Hash tables Binary search trees

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3		

COURSE NAME: CALCULUS - 3 **COURSE CONTACT HOURS: 3**
COURSE CREDIT HOURS: 3 **COURSE CODE: BSC MAT 201**

COURSE DESCRIPTION:

Calculus plays an important role in science, engineering, computer science, data engineering, artificial intelligence, economics, finance, and many other fields. This advanced calculus course extends upon the foundational concepts introduced in previous calculus courses, providing students with a deeper understanding of the subject matter. Through the mastery of calculus principles in this course, students will enhance their comprehension of the fundamental concepts that will be explored in subsequent advanced AI courses.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

This course is the third course in a four-course calculus sequence. Students who successfully complete this course may continue into "Calculus - 4", which is taught in the next semester. The objectives of this course are the following: to enable students to become a competent user of calculus concepts, to enable them to develop the ability to write well-organized, coherent solutions to problems, to enable them to understand the concepts of vector geometry

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. Describe mathematical equations using simple words (CO1)
2. Implement basic integration, integration by parts and of trigonometric functions (CO2)
3. Explain first order differential equation and solve them (CO3)
4. Interpret a point in a polar coordinates rather than Cartesian system (CO4)
5. Explain a curve as the path of an object mathematically (CO5)
6. Locate and trace a point in a three dimensional coordinate system (CO6)

LEARNING RESOURCES

Required Resources

•George B. Thomas, Jr. (with revisions by Joel Hass, Christopher Heil and Maurice D. Weir), "Thomas' Calculus", 14th Edition, Pearson, 2018.

COURSE CONTENT

Sr.No	Modules/ Units
1	Transcendental Functions
	Inverse Functions and their derivatives Natural Logarithms Exponential Functions Separable differential equations
2	Techniques of integration
	Basic Integration Integration by parts
3	First order Differential Equations
	Introduction
4	Polar coordinates
	Polar coordinates Areas and lengths in polar coordinates Conics in polar coordinates
5	Vector Geometry
	Vectors Dot product Cross product Lines and planes in space

L	T	P
1	2	

COURSE NAME: SQL PROGRAMMING **COURSE CONTACT HOURS: 3**
COURSE CREDIT HOURS: 3 **COURSE CODE: BSC CSE 203**

COURSE DESCRIPTION:

This course is primarily intended to develop practical, hands-on skills and competency in effectively using a relational database management system to solve specific tasks. Students acquire hands-on skills in a variety of techniques such as DDL, DML, DCL and using joins and aggregations, rollups to understand and manage data. Students are exposed to techniques such as concurrency control and backup and recovery options applied to a relational database management system. Overall, it prepares them with an effective and industry-ready hands-on training in SQL.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of the course are as follows:

- Understand the concepts of database architecture and design
- Assimilate concepts related to a myriad of different SQL features
- Develop hands-on competency in executing a multitude of querying techniques
- Understand and apply backup and recovery strategies
- Understand issues related to concurrency control and failure recovery

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. Understand in-depth the concepts of database architecture and design (CO1)
2. Assimilate concepts related to a variety of different SQL programming strategies (CO2)
3. Develop competency in executing queries using a multitude of SQL techniques (CO3)
4. Obtain an in-depth understanding of backup and recovery strategies (CO4)
5. Develop competency in handling issues related to concurrency control and failure recovery (CO5)

LEARNING RESOURCES

Recommended TextBooks

1. Learning MySQL by Seyed M.M. “Saied” Tahaghoghi and Hugh E. Williams, Oreilly, Nov 2006.
2. SQL/PLSQL for Oracle 9i by P.S. Deshpande, Dreamtech Press, Dec 2003.
3. MySQL Tutorial - MySQL By Examples for Beginners, NTU Singapore.

Recommended References:

- H Garcia-Molina, JD Ullman and Widom, Database Systems: The Complete Book,2nd Ed., Prentice-Hall, 2008.
- R Ramakrishnan, J Gehrke, Database Management Systems, 3rd Ed., McGraw-Hill, 2002.

COURSE CONTENT

Sr.No	Modules/ Units
1	Introduction
	Why Is MySQL so Popular, Elements of MySQL and Its Environment, Installing MySQL, The Database Design Process, The Entity Relationship Model, Entity Relationship Modeling Examples, Using the Entity Relationship Model
2	SQL Basics
	The SELECT Statement and Basic Querying Techniques, The INSERT Statement, The DELETE Statement, The UPDATE Statement, Exploring Databases and Tables with SHOW and mysqlshow, Creating and Using Databases, Creating Tables, Altering Structures
3	SQL Operators, Functions Constraints and Indexes
	Keys and Indexes, Adding, Removing and Changing Indexes, Renaming Tables, Removing Tables, Dropping Databases), Deleting Structures, Aliases, Aggregating Data, Rollup, Basic and Advanced Joins, Nested Queries, Subqueries, Date and String Functions, Case Expressions, Views, Inserting Data Using Queries, Loading Data from Comma-Delimited Files, Writing Data into Comma-Delimited Files, Creating Tables with Queries, Updates and Deletes with Multiple Tables, Replacing Data, The EXPLAIN Statement
4	Concurrency Control, User Management and Recovery
	Triggers, Managing Users and Privileges, Analytical Queries for Data Analysis, Lock Tables, Introduction to Stored Procedures, Backups and Recovery

L	T	P
2		

COURSE NAME: ENGLISH FOR BUSINESS AND TECHNICAL COMMUNICATIONS **COURSE CONTACT HOURS: 2**

COURSE CREDIT HOURS: 2 **COURSE CODE: BSC HUM 201**

COURSE DESCRIPTION:

English for Business and Technical Communication is at the core of professional skills. This Course aims at reflecting, learning, and exercising the skills and abilities for effective communication in English. The Case study, as part of the course, pushes the students to leverage and reflect on their current ability to communicate in English.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of this course are:

1. Develop communication skills to effectively collaborate with the others
2. Adopt suitable communication skills across settings, purposes, and audiences
3. Build and maintain healthy and effective relationships
4. Demonstrate appropriate and professional ethical behaviour

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. Understand the Basics of Business Communication (CO01)
2. Overcome barriers to effectiveness (CO02)
3. Employ the rules and patterns of intonation (CO03)
4. Offer & and acknowledge peer feedback (CO04)
5. Speak comprehensibly and present a short speech (CO05)
6. Avoid confusion in the message due to faulty pronunciation, grammar, or vocabulary
7. (CO06)
8. Use prewriting techniques to develop ideas and produce multiple drafts of different
9. types of paragraphs (CO07)
10. Complete writing exercises to express an understanding of readings (CO08)
11. Ask and answer questions, and ask for clarification (CO09)
12. Build and maintain healthy and effective relationships (CO10)
13. Demonstrate appropriate and professional ethical behaviour (CO11)

LEARNING RESOURCES

Recommended TextBooks

- Will be provided by the faculty

Recommended References:

COURSE CONTENT

Sr.No	Modules/ Units
1	Basics of Business Communication
	• Types and Ways of Communication • Elements of Communication • Effective Communication • Barriers to Effectiveness

2	Remedial Grammar & Vocabulary for Professional Communication
	● Complete sentence structure ● The rules of demonstratives ● Present, past, and future verb forms ● Question words and question format ● Words, Idioms, and phrases in the business context.
3	Networking and Corporate Scenarios
	● Build and maintain healthy and effective relationships. ● Demonstrate appropriate and professional ethical behaviour ● Deal with nerves and think more positively about public speaking ● Consider ways of grabbing the listener's attention, holding their interest, and concluding strongly

Semester 4

L	T	P
2		2

COURSE NAME: QUANTUM PHYSICS **COURSE CONTACT HOURS: 4**
COURSE CREDIT HOURS: 3 **COURSE CODE: BSC ASC 202**

COURSE DESCRIPTION:

This course provides a brief yet comprehensive introduction to quantum physics for non-physics majors, covering fundamental concepts like wave-particle duality, quantum entanglement, and the Schrödinger Equation. It focuses on the practical applications of these principles in modern technology and their philosophical implications. Emphasizing conceptual understanding over mathematical intricacies, the course aims to enhance scientific literacy and critical thinking through a blend of lectures and interactive resources.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

Students who successfully complete this course are prepared to build statistical models for some of the most common types of real-world Data Science problems – Prediction, Classification and Forecasting.
The objectives of this course are:

1. Understand Basic Principles: Grasp fundamental concepts like wave-particle duality, Uncertainty, Schrödinger Equation.
2. Learn Historical Development: Explore the history and key figures of quantum theory.
3. Discover Applications: See how quantum physics applies in technology like semiconductors and quantum computing, quantum entanglement, quantum teleportation, quantum information.
4. Evaluating and questioning quantum theories and experiments.
5. Engaging with Contemporary Research in quantum physics

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

- CO1: Students will understand key concepts like wave-particle duality, the Uncertainty Principle, and the Schrödinger Equation.
- CO2: Gain knowledge of the evolution of quantum theory and its significant contributors.
- CO3: Understand quantum physics applications in technologies like semiconductors and quantum computing, quantum entanglement, quantum teleportation, quantum information
- CO4: Develop skills to critically analyze quantum theories and experimental results.
- CO5 Stay updated and discuss recent advancements in quantum physics.

LEARNING RESOURCES

Required Text Reading

- None

Books

1. "Introduction to Quantum Mechanics" by David J. Griffiths
2. “Introduction to quantum physics, Quantum Physics For Dummies" by Steven Holzner
3. "Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher" by Richard P. Feynman
4. "In Search of Schrödinger's Cat: Quantum Physics and Reality" by John Gribbin
5. "The Quantum World: Quantum Physics for Everyone" by Kenneth W. Ford

Websites

https://plato.stanford.edu/entries/qt-entangle/
Introduction to Quantum computing
https://learning.edx.org/course/course-v1:UChicagoX+QUAN11000+3T2023/home

The Quantum Internet and Quantum Computers: How Will They Change the World?

https://courses.edx.org/courses/course-v1:DelftX+QTM1x+2T2023/ff920d5e362b4f07859fe282037dd371/#structure

COURSE CONTENT

Modules	
Introduction to Quantum Physics	
1.1	Black body radiation,
1.2	Explanation of it using the photon concept
1.3	Compton effect
1.4	Photoelectric effect
1.5	de Broglie hypothesis, Experiments demonstrating wave properties of electron
1.6	Uncertainty Principle
1.7	Uncertainty Principle. Wave-particle duality
1.8	Verification of matter waves, Uncertainty principle.
Schrodinger equation	
2.1	Basic postulates of quantum mechanics
2.2	concept of wave function
2.3	Superposition principle of eigenstates
2.4	Concept of collapse of wave function
2.5	Time dependent and time independent Schrodinger Equation

2.6	Concept of free particle
2.7	Particle in an infinite and finite potential well
2.8	Concept of Quantum Tunnelling
2.9	Few realistic examples of tunnelling, e.g., alpha decay, Probe microscopes (Scanning Tunnelling microscope). Simple Harmonic Oscillator, explanation in 1D (no detailed derivation).
Introduction to Quantum Physics in Technology	
3.1	Basic Concepts: Wave-Particle Duality, Superposition, Entanglement
3.2	Introduction to Quantum and Classical Computing
3.3	Quantum Physics in Semiconductors
3.3.1	Role of Quantum Mechanics in Semiconductor Technology
3.3.2	Applications in Electronics and Photovoltaics
3.4	**Fundamentals of Quantum Computing**
3.4.1	Principles of Quantum Computing
3.4.2	Quantum Bits (Qubits) vs Classical Bits
3.4.3	Quantum Gates and Circuits
3.5	**Quantum Entanglement and Communication**
3.5.1	Exploring Quantum Entanglement
3.5.2	Applications in Quantum Communication

3.5.3	Quantum Cryptography and Security
3.6	**Quantum Teleportation**
3.6.1	Concept and Basic Principles of Quantum Teleportation
3.6.2	Theoretical Framework and Experimental Achievements
3.6.3	Potential Applications and Future Prospects
3.7	**Quantum Information Theory**
3.7.1	Basics of Quantum Information
3.7.2	Quantum Information Processing
3.7.3	Impact on Data Transmission and Encryption
	Current Trends and Future Applications
4.1	Latest Developments in Quantum Technologies
4.2	Potential Future Applications and Innovations
4.3	Ethical and Societal Implications
	Revision
	Revision

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COURSE NAME: INTRODUCTION TO ALGORITHMS COURSE CONTACT HOURS: 5

COURSE CREDIT HOURS: 3 COURSE CODE: BSC CAP 202

COURSE DESCRIPTION:

This course introduces the common algorithm design strategies used to solve computational problems. The relationship between algorithms and programming is emphasized, and basic performance measures and analysis techniques for these problems are introduced. Topics covered include greedy algorithms, divide and conquer algorithms, quicksort, dynamic programming, representations of graphs, breadth-first search, depth-first search, minimum spanning trees, and Dijkstra's algorithm.

Pre-requisites: Data Structures, Linear Algebra, Mathematics for Computer Science, and Introduction to Computer Science and Programming - 1

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

After completing this course, students will be able to explain and apply the fundamental algorithm design techniques that are often used in many applications. These concepts will be used in subsequent courses in computation, software engineering, and computer systems

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

- Demonstrate expertise in solving problems using the divide and conquer strategy, breaking down complex problems into simpler sub-problems and effectively combining solutions (CO1)

- Apply greedy algorithms to solve optimization problems, making locally optimal choices at each stage to achieve a globally optimal solution (CO2)
- Demonstrate proficiency in using dynamic programming to solve problems by breaking them down into overlapping sub-problems, efficiently storing and reusing solutions (CO3)
- Demonstrate mastery in selecting and constructing minimum spanning trees in graphs using algorithms like Kruskal's and Prim's, showcasing efficiency in graph optimization (CO4)
- Apply algorithms to find the shortest paths in graphs, demonstrating proficiency in techniques such as Dijkstra's algorithm and Bellman-Ford algorithm (CO5)
- Evaluate and analyze problems and select or design appropriate algorithms based on the problem's characteristics and requirements (CO6)

LEARNING RESOURCES

Required Resources

- A. V. Aho, J. E. Hopcroft, and J. E. Ullman, "Data Structures and Algorithms", Pearson India, 2002. [AHU]
- T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to Algorithms", Fourth Edition, MIT Press, 2022. [CLRS]None

Books

- T. Roughgarden, The "Algorithms Illuminated" Book Series (Parts 1 to 4), 2017. https://www.algorithmsilluminated.org
- S. Dasgupta, C. Papadimitriou, and U. Vazirani, "Algorithms", Tata McGraw-Hill, 2008. Freely downloadable from http://algorithmics.lsi.upc.edu/docs/Dasgupta-Papadimitriou-Vazirani.pdf
- D. Knuth, "The Art of Computer Programming, Volume 1: Fundamental Algorithms", Third Edition, Addison-Wesley, 1997.
- D. Knuth, "The Art of Computer Programming, Volume 3: Sorting and Searching", Second Edition, Addison-Wesley, 1998.
- A. Bell, E. Grimson, and J. Guttag. 6.0001, "Introduction to Computer Science and Programming in Python", Fall 2016. MIT OpenCourseWare, https://ocw.mit.edu
- J. Guttag, "Introduction to Computation and Programming Using Python with Application to Understanding Data", Second Edition, MIT Press, 2016.
- J. Leskovec, A. Rajaraman, and J. Ullman, "Mining of Massive Datasets", Third Edition, 2019. Free download from http://mmds.org.
- https://ourcodingclub.github.io/tutorials/time/

COURSE CONTENT

Unit	Modules
1	**Divide and conquer algorithms, quicksort**

2	**Greedy algorithms**
3	**Dynamic programming**
4	**Representations of graphs, breadth-first search**
5	**Depth-first search, special types of graphs**
6	**Minimum spanning trees**
7	**Shortest paths, Dijkstra's algorithms**
8	**Final project presentation**

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COURSE NAME: STATISTICS AND PROBABILITY IN COURSE DECISION MODELING - 2

CONTACT HOURS: 3

COURSE CREDIT HOURS: 2

COURSE CODE: BSC DSC 202

COURSE DESCRIPTION:

This course offers a comprehensive exploration of key concepts in machine learning and statistical modeling, focusing on foundational principles and practical applications. The course begins with an in-depth examination of the Bias-Variance Tradeoff, providing students with a nuanced understanding of how model complexity influences prediction errors. Moving on to regularization techniques such as Ridge, LASSO, and Elastic Nets, students learn how to mitigate overfitting and enhance model generalization. The curriculum then delves into Dimensionality Reduction using Principal Components Analysis (PCA), elucidating the essential role of feature selection and extraction in managing high-dimensional datasets. Finally, the course addresses Time Series Forecasting methods, equipping students with the skills to analyze temporal patterns and make accurate predictions in dynamic environments. Through a combination of theoretical lectures and hands-on exercises, students gain a robust foundation in these fundamental machine learning concepts, empowering them to apply these methods across various domains.
Pre-requisites: Foundations of Probability and Statistics for Data Science – 1, Foundations of Probability and Statistics for Data Science – 2, Statistics and Probability in Decision Modeling - 2

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

Students who successfully complete this course are prepared to evaluate the performance of statistical and machine learning models in real-world situations, and to take corrective measures to minimize errors and improve performance. They learn to build more advanced regression models as also to handle very high dimensional datasets. They also learn to build models for making forecasts where time is a key factor.
The objectives of this course are:

- To understand bias and variance of models and learn the techniques used to balance the two.
- To build advanced regression models using regularization.
- To understand the concept of Principal Components Analysis and use it to reduce the dimensionality of the dataset.

- To understand time series data and different components of the same.
- To know when not to use regression in time-series data, which leads to spurious correlations.
- To build sophisticated models of time series data and make forecasts using real-world data.

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

CO1: Explain k-fold cross validation, bias-variance tradeoff, evaluate model performance in unseen data and analyze errors to identify if the error is due to bias or variance.
CO2: Explain the concept of regularization and build advanced regression models with Python using regularization.
CO3: Understand the concept of Principal Components Analysis and use it to reduce the dimensionality of the data sets for use in various ML models using Python.
CO4: Understand and explain time series concepts and make forecasts on real-world data using basic models that utilize regression and moving average concepts.
CO5: Understand and explain concepts behind advanced time series forecasting models and make forecasts on real-world data using Python.
CO6: Know when and why not to use regression models in time series data, build sophisticated models incorporating exogenous (independent) variables, and make forecasts on real-world data using Python.

LEARNING RESOURCES

Required Resources

Required Text Reading

- None

Books

- Norman Matloff. *Statistical Regression and Classification: From Linear Models to Machine Learning*, First Edition, Chapman and Hall/ CRC Press. 2017
- Rob J Hyndman, George Athanosopoulos. *Forecasting: Principles and Practice*, Second Edition. https://otexts.com/fpp2/

Websites

- https://heartbeat.fritz.ai/deep-learning-best-practices-regularization-techniques-for-better-performance-of-neural-network-94f978a4e518
- https://www.analyticssteps.com/blogs/l2-and-l1-regularization-machine-learning
- https://bradleyboehmke.github.io/HOML/pca.html
- https://ourcodingclub.github.io/tutorials/time/

COURSE CONTENT

Unit	Modules	
1	**Model Performance Evaluation**	
	1.1	Bias-Variance tradeoff
	1.2	K-fold cross-validation
2	**Advanced Regression and Dimensionality Reduction**	
	2.1	Regularization
	2.2	Principal Components Analysis (PCA)
3	**Time Series Forecasting**	
	3.1	Basic time-series models: Using Regression; Using Moving Averages
	3.2	Advanced time-series models: ETS, (S)ARIMA
	3.3	Spurious Regression
	3.4	Granger Causality
	3.4	Advanced time-series models using exogenous (independent) variables: (S)ARIMAX / Regression with (S)ARIMA Errors
	3.5	Case study

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COURSE NAME: COMPUTER ORGANISATION AND ARCHITECTURE **COURSE CONTACT HOURS: 4**

COURSE CREDIT HOURS: 3 **COURSE CODE: BSC CAP 204**

COURSE DESCRIPTION:

This Computer Organization and Architecture course offers an in-depth study of computer architecture and system management, tailored for computer science students. It focuses on understanding computer system components such as CPUs, memory, and I/O devices, and applying performance metrics for system evaluation. The course delves into various computer architectures, examining their impact on performance. Key topics include process management, covering scheduling, synchronization, and deadlock resolution, and memory management techniques. Through a blend of theory and practical application, including lectures and lab sessions, students gain essential skills for optimizing computer system efficiency, preparing them for advanced studies or careers in technology.

Pre-requisites: Basic Knowledge of Digital Electronics and Microprocessors

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

Students who successfully complete this course are prepared to build statistical models for some of the most common types of real-world Data Science problems – Prediction, Classification and Forecasting.

The objectives of this course are:

1. Understand Systems in Software Development: Grasp the influence of computer organization and operating systems on software development.
2. Analyze Computer Architecture Impact: Learn how computer architecture affects software performance and design.
3. Explore OS Principles for Software Development: Understand operating system concepts and their impact on software functionality.
4. Link Software Performance to System Features: Develop skills to correlate software performance with system-level features like architecture and OS design.
5. Apply Theory Practically: Enhance problem-solving skills in software development, considering system constraints.

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. **CO1: Develop a comprehensive understanding of the basic components of computer system**
2. **CO2:** A**pply** the knowledge of performance metrics to find the performance of systems..
3. **CO3: Examine** different computer architectures and hardware
4. **CO4**: **Analyse** and compare of process management concepts including scheduling, synchronization, deadlocks.
5. **CO5: Analyse** and compare various memory management techniques

LEARNING RESOURCES

Required Text Reading

- None

Books

- Stallings William, Computer Organization & Architecture, Pearson Education, 10th Ed. 2013
- A Silberschatz, Abraham and others, Operating Systems Concepts, Wiley Student Edition, 9th Ed.Norman Matloff.
- Patterson, David A & J L Hennenssy, Computer Organization and Design – The Hardware/Software Interface, Elsevier, Revised 4th Ed.
- Randal E. Bryant, David R. O'Hallaron, Computer Systems – A Programmer's Perspective, Pearson, 2nd Ed, 2016.
- Kai Hwang and Briggs, Computer Architecture and Parallel Processing, Tata McGrawHill Edition
- Stallings, Operating Systems: Internals and Design Principles, International Edition, Pearson Education, 2013 (Pearson Online)

COURSE CONTENT

Unit	Modules	
1	**Introduction to Computer Systems**	
	1.1	Basic Operational concepts, Bus structures.
	1.2	Basic uniprocessor and Multi-processor Architecture
	1.3	Instruction Cycle State Diagram
	1.4	Embedded Systems
	1.5	Arm Architecture
	1.6	Cloud Computing

	1.7	Microprocessors versus Microcontrollers
	1.8	Performance Assessment- MIPS Rate
	1.9	Amdahl's Law
2	**Computer Architecture and Organization**	
	2.1	Von-Neumann Architecture vs Harvard Architecture
	2.2	RISC Vs CISC
	2.3	Machine Instruction Characteristics
	2.4	Types of Operands, Operations and Addressing Modes
	2.5	Instruction Formats
	2.6	**Register Transfer Language and Micro Operations-Introduction**
	2.7	RTL- Registers, Register transfers, Bus and memory transfers.
	2.8	Micro operations: Arithmetic, Logic, and Shift micro-operations, Arithmetic logic shift unit.
	2.9	Computer Registers, Computer instructions, Instruction cycle.
	2.10	Instruction codes, Timing and Control, Types of Instructions: Memory Reference Instructions, Input – Output and Interrupt
3	**Computer Organization and Design : Memory Organization, CPU and Cache**	
	3.1	Internal Memory - o Semiconductor Main Memory (SRAM and DRAM) o DDR – DRAM
	3.2	External Memory – o Magnetic Disk, RAID o SSD - Solid State Memory Technologies (Types)
	3.3	Cache Memory Organization o Locality (Class Notes) o Locality of Reference to Program Data o Locality of instruction fetches

		Memory Hierarchy Cache Memories o Generic Cache Memory Organization o Direct Mapped Cache
	3.4	Cache Memory Organization o Fully Associative Cache o Set Associative Caches o Issues with Writes o Performance Impact of Cache Parameters
	Process Management	
4.	4.1	Concept of Process
	4.2	Process State Diagram
	4.3	Operations on Processes : Process creation and termination examples
	4.4	Process vs. Threads
	4.5	Process Scheduling criteria
	4.6	Process Scheduling Algorithms -FCFS, SJF
	4.7	**Introduction to Process Coordination**
		Semaphores
		Deadlock
5.		**Memory and Input –Output Management**
	5.1	Memory-Management Strategies
	5.2	Paging
	5.3	Segmentation
	5.4	Virtual-Memory
	5.5	Demand Paging

	5.6	Page Replacement Algorithms: FIFO, Optimal, LRU, and LFU
	5.7	Input –Output Organization: Peripheral devices, Input-output subsystems, I/O
	5.8	device interface, interrupts and exceptions. I/O device interfaces – SCII, USB

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COURSE NAME: APPLYING ML TO BIG DATA USING HADOOP AND SPARK ECOSYSTEMS **COURSE CONTACT HOURS: 3**
COURSE CREDIT HOURS: 4 **COURSE CODE: BSC DSC 204**

COURSE DESCRIPTION:

This course provides a comprehensive understanding of Big Data, encompassing the storage, retrieval, and processing of large datasets. Emphasis is placed on exploring the technologies, including tools and algorithms, available for effectively managing and processing Big Data. Additionally, the course equips students with the skills to conduct diverse analytics on various datasets, leading to informed and positive conclusions.
Pre-requisites: Basics of Python and SQL
Year and Term: Second Year and Fourth Sem

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

The objectives of the course are as follows: Students will be able

- To understand big data.
- To learn MapReduce analytics using Hadoop
- To understand the overview of Apache Hadoop and its ecosystem
- To understand the basic architecture of Spark.
- To Understand Spark ML and its role in machine learning

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. **(CO1)** Understand the fundamental concepts of Big Data and Hadoop Architecture
2. **(CO2)** Utilize Spark for data processing

3. **(CO3)** Work with Spark RDD and data frames
4. **(CO4)** Utilize Spark ML for large-scale data analysis.
5. **(CO5)** Acquire skills in working with distributed storage and querying tools such as Hive and HBase.

LEARNING RESOURCES

Required Resources

Textbooks

1. Hadoop Operations - Eric Sammer – 2012 First Edition - ISBN: 978-1-449-32705-7

2. Spark: The Definitive Guide - Big Data Processing Made Simple -Bill Chambers and Matei Zaharia, 2018 First Edition – ISBN 978-1-491-91221-8

3. Programming Hive Edward Capriolo, Dean Wampler, and Jason Rutherglen-ISBN: 978-1-449-31933-5

Recommended References

- Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
- Boris Lublinsky, Kevin T. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.

COURSE CONTENT

Unit	Modules	
1	**Introduction to Big Data and Hadoop**	
	1.1	Introduction - Distributed file system
	1.2	Big Data importance, Vs of Big Data, Applications
	1.3	Apache Hadoop & Hadoop Eco System
	1.4	Data Serialization- Hadoop Architecture
	1.5	Hadoop Storage - Hadoop Map Reduce
	1.6	Understanding the Map Reduce architecture
	1.7	Map and Reduce tasks, Job, Task trackers
2	**Spark Architecture**	

	2.1	Parallel Processing Engines: Spark basic Architecture
	2.2	Spark on Yarn - Spark APIs
	2.3	Spark Session - Data frames
	2.4	Transformations - Actions – Spark UI
	2.5	End to End to Example
3	**Spark RDD**	
	3.1	Spark RDD - Creating RDD, Apply Transformation & Actions
	3.2	Spark RDD - To find the frequency of Word - Spark Data frame API
	3.3	Construction of Spark Data frames using RDDs-Spark Data frame API
	3.4	Reading the Spark data sources (CSV, JSON, etc.) to construct Spark Data frames Spark Data frame API
	3.5	Transformation & Action- DF functions
	3.6	Aggregate operations-Spark Data frame API
	3.7	Date and Time Stamp-Random Sample & Split-Handling missing values
	3.8	Sorting and Union - Spark SQL API - Understanding User Defined Functions (UDF's) in Spark Data frames - Broadcast variables.
4	**Spark ML**	
	4.1	SparkML – Introduction to Transformers in Spark ML
	4.2	Data Analysis using Spark Data Frames - SparkML
	4.3	Building a Pipeline & Machine Learning Algorithm using Spark Data frames - Regression
	4.4	Spark ML – Advanced ML Models - Decision Tree
	4.5	Spark ML – Random Forest - K-Means
5	**Introduction to Hive**	
	5.1	Hive Architecture and Installation, Comparison with Traditional Database

	5.2	HiveQL - Querying Data - Sorting And Aggregating
	5.3	Map Reduce Scripts, Joins & Subqueries
	5.4	Joins & Subqueries, HBase concepts- Advanced Usage, Schema Design, Advance Indexing - PIG, Zookeeper

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COURSE NAME: CALCULUS – 4 **COURSE CONTACT HOURS: 2**

COURSE CREDIT HOURS: 2 **COURSE CODE: BSC MAT 202**

COURSE DESCRIPTION:

Calculus IV, an advanced course in multivariable calculus, expands upon the foundational concepts introduced in earlier calculus courses. This course is designed to provide students with a comprehensive understanding of multivariable functions, vector calculus, and their applications in various fields.

Pre-requisites: Calculus – 1, Calculus – 2, Calculus – 3

Year and Term: Second Year and Second Term

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

Students who successfully complete this course are prepared to acquire a solid grasp of advanced multivariable calculus concepts and their applications, laying the groundwork for success in scientific and engineering disciplines. The emphasis on both theoretical understanding and practical application ensures students are well-prepared for the complexities of real-world problem-solving.

The objectives of this course are:

1. Objectively assess and solve problems involving functions of several variables, exploring critical concepts such as gradients, directional derivatives, and optimization.
2. Apply vector calculus techniques to model and analyze physical phenomena, emphasizing the relevance of vectors in representing motion, curves, and surfaces in three-dimensional space.
3. Apply integration methods to solve problems related to area, volume, and mass distribution, demonstrating a comprehensive understanding of multivariable integration.
4. Utilize mathematical modeling to address challenges in physics, engineering, and other scientific domains, fostering an appreciation for the interdisciplinary nature of real-world problem.

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

1. CO1: Develop a strong mathematical foundation in generating curves in 2D and 3D space coordinate systems and relating them to the motion of objects in space.
2. CO2: Utilize vector calculus principles to draw tangential and normal components of the velocity and acceleration of a moving object in space.
3. CO3: Utilize Double and Iterated Integrals over Rectangles, enabling students to find the arc length and the area of a closed region using double integrals.
4. CO4: Understand the application of triple integrals to calculate the volumes of regions enclosed by 3D surfaces.
5. CO5: Solve problems related to Circulation, flux and work using the concept of integrals of vector fields. And apply definite integrals in practical scenarios.
6. CO6: Use the concept of integrals of vector fields to find real-life applications of volume expansion or compression, uniform or non-uniform rotation, shearing flow and whirlpool effect in a flowing fluid.

LEARNING RESOURCES

Required Text Reading

- None

Books

1. “Thomas’ Calculus”, George B. Thomas, Jr., 14th Edition, Pearson, 2018
2. “Calculus”, Gilbert Strang, Wellesley-Cambridge Press, MIT Open Courseware
3. “Advanced Engineering Mathematics”, Erwin Kreyszig, 10th Edition, John Wiley & Sons Inc., 2011

Calculus relating to AI & ML

1. "Mathematics for Machine Learning" by Marc Peter Deisenroth, A Aldo Faisal, Cheng Soon Ong:
2. "Essential Mathematics for Artificial Intelligence" by Jeffrey L. Heaton
3. "Calculus for Machine Learning" by Hal Varian

COURSE CONTENT

Unit	Modules	
1	**Vector-Valued Functions and Motion in Space**	
	1.1	Curves in Space and Their Tangents, Integrals of Vector Functions; Projectile Motion
	1.2	Arc Length in Space, Curvature and Normal Vectors of a Curve
	1.3	Tangential and Normal Components of Acceleration, Velocity and Acceleration in Polar Coordinates
2	**Partial Derivatives**	
	2.1	Functions of Several Variables
	2.2	The Chain Rule, Partial Derivatives
	2.3	Directional Derivatives and Gradient Vectors
	2.4	Tangent Planes and Differentials
	2.5	Partial Derivatives with Constrained Variables
3	**Multiple Integrals**	
	3.1	Double and Iterated Integrals over Rectangles
	3.2	Area by Double Integration
	3.3	Double Integrals over General Regions
	3.4	Triple Integrals in Rectangular Coordinates
	3.5	Applications
4.	**Integrals and Vector Fields**	

	4.1	Line Integrals of Scalar Functions
	4.2	Surfaces and Area, Surface Integrals
	4.3	Green's Theorem in the Plane
	4.4	Stokes' Theorem

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COURSE NAME: Life Skills - COMMUNICATION, ETHICAL AND IP CHALLENGES FOR ANALYTICS PROFESSIONALS **COURSE CONTACT HOURS: 2**
COURSE CREDIT HOURS: 2 **COURSE CODE: BSC LS 02**

COURSE DESCRIPTION:

This course examines the communication, ethical, and intellectual property challenges faced by analytics professionals in today's data-driven world. Students will learn effective strategies for communicating analytics findings to non-technical audiences in a clear and compelling manner. The course covers data visualization techniques, storytelling with data, and tailoring messaging for different stakeholders.
Students will evaluate real-world case studies that highlight current ethical issues in areas like privacy, informed consent, and algorithmic bias. The course provides frameworks for ethical decision-making and explores ways to build ethics into the entire analytics lifecycle. Intellectual property concerns and data ownership issues will also be discussed.
By the end of the course, students will be able to communicate analytics insights through visual, written and oral formats. They will have the knowledge to make ethical decisions in complex situations related to data analytics. And they will understand how to protect intellectual property and manage data rights and permissions

Pre-requisites:

- Introduction to Data Analytics: Students should have a basic understanding of data analytics concepts, methods, and tools. This provides the foundation to then explore communication and ethical implications.
- Statistics: Having prior coursework in statistics helps ensure students can interpret quantitative information and analytics outputs.
- Technical Writing: Strong written communication skills are essential. A prior technical writing course enables students to build on that ability.

- Ethics: Previous ethics coursework helps students analyze moral implications and make ethical decisions related to data and analytics.
- Intellectual Property: Basic knowledge regarding copyright, trademarks, patents, and data ownership rights is useful context for the intellectual property components of the course.
- Programming or Databases: Some programming or database experience gives students better insight into data storage, manipulation, security, and privacy concerns that may arise.

COURSE AIMS, LEARNING OBJECTIVES, AND GRADUATE ATTRIBUTES

- Introduce communication modalities and skills needed for analytics professionals
- Teach principles and tools for impactful data storytelling and visualization
- Discuss ethical regulations, frameworks and use cases for data analysis
- Explain different types of biases and techniques to address them
- Outline Indian and international IP laws relevant to data and analytics
- Enable effective collaboration in multi-disciplinary analytics teams

COURSE OUTCOMES

After the successful completion of this course, the students should be able to:

- Demonstrate effective verbal, written and interpersonal communication skills required for
- analytics professionals
- Develop engaging data stories and visualizations to communicate insights
- Evaluate ethical concerns around data analysis and algorithms
- Identify and mitigate biases in data science workflows
- Understand intellectual property regulations and protection for analytics IP
- Apply collaboration methodologies and resolve conflicts effectively in analytics teams

LEARNING RESOURCES

Required Text Reading

- None

Books

- Storytelling with Data by Cole Nussbaumer Knaflic
- Weapons of Math Destruction by Cathy O'Neil
- Creative Commons licenses explained
- ISO standards on data visualization, data quality and analytics

Online Resources:

Analytics Vidhya blogs and discussion forums
Kaggle discussion boards on ethics and bias in data science
Creative Commons videos and tutorials
WIPO resources on intellectual property

Case studies on analytics collaboration from Harvard Business Review

COURSE CONTENT

Unit	Modules	
1	**Introduction to Communication Skills**	
	1.1	Importance of communication skills for analytics professionals Verbal communication - presentations, meetings, interviews
	1.2	Written communication - emails, reports, documentation Interpersonal communication skills
2	**Data Storytelling and Visualization**	
	2.1	Principles of effective storytelling with data Tools and best practices for data visualization
	2.2	Presenting insights through dashboards, infographics
3	**Ethical Use of Data and Analytics**	
	3.1	Privacy, bias and other ethical concerns with data analysis
	3.2	Fairness, transparency and accountability in algorithms
	3.3	Ethical use cases and frameworks for analytics
	3.4	Privacy regulations like GDPR relevant to Indian professionals
	Bias and Diversity in Data Science Teams	
	4.1	Understanding cognitive biases and their impact on analysis
	4.2	Diversity and inclusion best practices for analytics teams

	4.3	Mitigating bias in data collection, modeling and reporting
5	**Intellectual Property for Analytics**	
	5.1	Basics of patents, copyright and trademarks
	5.2	IP protection for data, algorithms, models, code
	5.3	Open source licensing and IP considerations
	5.4	Indian IP regulations and compliance
	Effective Collaboration in Analytics	
	6.1	Team dynamics for analytics - roles, norms and values
	6.2	Collaborating with stakeholders - clients, leadership, other teams
	6.3	Agile, design thinking and other collaborative methodologies
	6.4	Conflict resolution and communication during disagreements