ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం आंध्रप्रदेश केंद्रीय विश्वविद्यालय

CENTRAL UNIVERSITY OF ANDHRA PRADESH

(Established by an act of Parliament in 2019)

SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES

DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE

Undergraduate Programme Structure
as per the UGC Credit Framework (NEP 2020)

Vidya Dadati Vinayam
(Education gives humility)

B.Sc. (Hons.) Computer Science and Artificial Intelligence

"Today's AI is about new ways of connecting people to computers, people to knowledge, people to the physical world,and people to people."

- Patrick Winston

Programme Structure
(With effect from AY 2024 - 25)

CONTENTS

SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES
DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE
B. Sc (Hons) Computer Science and Artificial Intelligence

Introduction to the Programme

B. Sc (Hons) Computer Science and Artificial Intelligence is one of the new undergraduate programmes being offered by CUAP from 2024-25 academic year and the programme is designed as per NEP guidelines with multiple exit options. This Programme is an interdisciplinary field that combines the fundamentals of computer science with the cutting-edge technologies of artificial intelligence (AI). This program offers students a comprehensive understanding of both the theoretical foundations and practical applications of computer science and AI. Throughout the programme, students delve into various aspects of computer science, including programming languages, algorithms, data structures, computer architecture, and software engineering. Additionally, they explore the intricacies of artificial intelligence, including machine learning, deep learning, natural language processing, Blockchain Technologies, fundamentals of Data Science.

By integrating these two fields, Computer Science and Artificial Intelligence equips students with the knowledge and skills needed to tackle complex challenges in the digital age. Graduates of this programme are well-prepared to pursue diverse career paths in industries such as technology, healthcare, finance, gaming, and more. Overall, this program offers a dynamic learning experience that empowers students to become proficient computer scientists and AI specialists, ready to innovate and shape the future of technology.

Programme Objectives

- Provide students with a comprehensive understanding of computer science principles and theories, coupled with specialized knowledge in artificial intelligence technologies.
- Foster critical thinking and problem-solving skills by engaging students in practical applications and real-world challenges in computer science and AI domains.
- Equip students with the necessary technical expertise to develop innovative solutions leveraging artificial intelligence techniques for various applications.
- Prepare graduates for successful careers in industries such as technology, data science, robotics, and AI research, as well as for further academic pursuits in related fields.

Programme Learning Outcomes

On successful completion of the programme student should be able to:

- Understand the core principles and advanced theories spanning across the disciplines of Computer Science and Artificial Intelligence, including foundational topics such as Data Structures, Algorithms, Computer Architecture, Software Engineering, as well as advanced concepts in Artificial Intelligence, Machine Learning, Speech Processing, Natural Language Understanding and Robotics.
- Integrate knowledge from diverse fields including AI, Machine Learning, and Data Engineering to design innovative and efficient systems that address complex real-world problems.
- Demonstrate readiness to pursue further education and research in Artificial Intelligence, staying abreast of emerging technologies and methodologies, and contributing to the advancement of AI for the betterment of society.

Pedagogy of the Program

The pedagogy of the program is designed with an amalgamation of Student-Centric Learning, Group Discussions focusing on contemporary issues in Computer Science and Artificial Intelligence, Interactive Sessions, Internships and Project-based Learning, Research Orientation, Seminars & Workshops on current advancements, Tutorial & Assignments, and Class tests/Open book tests. Its objective is to furnish students with essential knowledge, skills, and competencies required to thrive in various roles within the realm of Computer Science and Artificial Intelligence. The combination of theoretical understanding, hands-on experiences, and immersive opportunities equips students to adeptly navigate intricate technological landscapes and contribute significantly to their organizations and society at large.

Programme Structure

- The B. Sc (Hons) Computer Science and Artificial Intelligence programme is a four-year course divided into eight semesters with a total of around 169 credits.
- The programme is designed with the combination of Core Courses, Minor Courses, Inter-disciplinary Electives (IDE), Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC) and Value-Added Courses (VAC).
- Students will undergo for two-month summer internship after semester IV and submit internship report in semester V.
- In semester VIII students will undergo Project Work / Dissertation.

SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES

DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE

B. Sc (Hons) Computer Science and Artificial Intelligence Semester and Course Wise Credits

Semester	Discipline Specific Core (Major) (DSC) (L+T+P)	Discipline Specific Minor (DSM) (L+T+P)	Inter-Disciplinary Courses (IDE)	Ability Enhancement courses (AEC)	Skill Enhancement courses /Internship /Dissertation	Common Value Added Courses	Internship	Dissertation	Total Credits
I	DSC 1 (4) DSC 2 (4)	DSM 1 (4)	MOOCs (3)	AEC 1 (2)	SEC 1 (3)	VAC 1 (2)	-		22
II	DSC 3 (4) DSC 4 (4)	DSM 2 (4)	MOOCs (3)	AEC 2 (2)	SEC 2 (3)	VAC 2 (2)	-		22
III	DSC 5 (4) DSC 6 (4)	DSM 3 (4)	MOOCs (3)	AEC 3(2)	SEC 3 (4)	-			21
IV	DSC 7 (4) DSC 8 (4)	DSM 4 (4)	-	AEC 4 (4)		VAC 3 (2)	Internship (2)		20
V	DSC 9 (4) DSC 10 (4) DSC 11 (4) DSC 12 (4) DSC 13 (3) MOOC	DSM 5 (4)	-	-	-	-	-		23
VI	DSC 13 (4) DSC 14 (4) DSC 15 (4) DSC EL-I (4)	DSM 6 (4)	-	-	-	-	-	Dissertation I (4)	24
VII	DSC 16 (4) DSC 17 (4) DSC EL-II (4)	DSM EL-I (4) DSM EL-II (4)	-	-	-		-	--	20
VIII	DSC 18 (4) DSC EL-III (4)	-	-	-	-		-	Dissertation II (12)	20
Total	**87**	**32**	**9**	**10**	**10**	**6**	**2**	**16**	**172**
Percentage	**50..58**	**18.60**	**5.23**	**5.81**	**5.81**	**3.48**	**1.16**	**9.30**	**100**

As per UGC Credit Framework, Major: 80 Credits, Minor: 32 Credits, Credits, AEC: 8 Credits, SEC: 9 Credits, VAC: 6/8 Credits, Internship: 2/4 credits, Dissertation: 12 credits. Minimum Total Credits per Programme :160

Programme Structure as per UGC Credit Framework

Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
Semester I						
1	BCS 101	Computer Fundamentals & Programming in C	4	3	0	1
2	BCS 102	Discrete Mathematics	4	3	1	0
3	BCS 111	Minor: Fundamentals of AI and Applications	4	3	1	0
4	BCS 112	MOOCs (IDE)	3	3	0	0
5	BCS 113	AEC: Human Rights and Duties	2	2	0	0
6	BCS 114	SEC: Modern English Grammar & Pronunciation	3	2	1	0
7	BCS 115	VAC: Indian Knowledge System (MOOCs)	2	2	0	0
Total			**22**	**18**	**3**	**1**
Semester II						
1	BCS201	Introduction to OOPs Using C++	4	3	0	1
2	BCS202	Web Technologies	4	3	0	1
3	BCS 211	Minor: Introduction to Machine Learning	4	3	1	0
4	BCS 212	MOOCs (IDE)	3	3	0	0
5	BCS 213	AEC: Understanding Disabilities	2	2	0	0
6	BCS 214	SEC: Academic Writing	3	2	1	0
7	BCS 215	VAC: Ecology & Environment	2	2	0	0
Total			**22**	**18**	**2**	**2**
Semester III						
1	BCS 301	Introduction to Java Programming	4	3	0	1
2	BCS 302	Computer Organization and Architecture	4	3	0	1
3	BCS 311	Minor: Introduction to Deep Learning	4	3	1	0
4	BCS 312	MOOCs (IDE)	3	3	0	0
5	BCS 313	AEC: Understanding Indian Economy	2	2	0	0
6	BCS 314	SEC: Introduction to Python Programming	4	3	0	1
Total			**21**	**17**	**1**	**3**

Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
Semester IV						
1	BCS 401	Operating Systems	4	3	0	1
2	BCS 402	Fundamentals of Data Structures	4	3	0	1
3	BCS 411	Minor: Natural Language Processing	4	3	1	0
4	BCS 412	AEC: Building Mathematical Ability and Financial Literacy	4	4	0	0
5	BCS 413	VAC: Climate Change or any other related course (online)	2	2	0	0
6	BCS 414	Summer Internship Project (SIP)	2	2	0	0
Total			**20**	**17**	**1**	**2**
Semester V						
1	BCS 501	Database Management Systems	4	3	0	1
2	BCS 502	Fundamentals of Data Science using Python	4	3	0	1
3	BCS 503	Design and Analysis of Algorithms	4	3	1	0
4	BCS 504	Basics of Cloud Computing	4	3	1	0
5	BCS 505	MOOCs	3	3	-	-
6	BCS 511	Minor: Ethics and Social Implications of Artificial Intelligence	4	3	1	0
Total			**23**	**18**	**3**	**2**
Semester VI						
1.	BCS 601	Data Mining & Data Warehousing	4	3	0	1
2.	BCS 602	Computer Networks	4	3	0	1
3.	BCS 603	Introduction to Information Security	4	3	1	0
4	**Any one of the following Electives: (Major Elective-I)**		4	3	1	0
	BCS 604	Advanced Database Management Systems				
		Distributed Systems				
		Fundamentals of IoT				
5	BCS 611	Minor: Data Analysis and Visualization	4	3	1	0
6	BCS 612	Dissertation -I	4	0	0	4
Total			**24**	**15**	**3**	**6**

Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
Semester VII						
1.	BCS 701	Advanced Java Programming	4	3	0	1
2.	BCS 702	Software Engineering	4	3	0	1
3	**Any one of the following Electives: (Major Elective-II)**		4	3	1	0
	BCS 703	Mobile Application Development				
		Introduction to Blockchain Technology				
		Fundamentals of Digital Forensics				
		Introduction to Large Language Models (MOOC/SWAYAM)				
4	**Any one of the following Electives: (Minor Elective-I)**		4	3	1	0
	BCS 711	Introduction to Reinforcement Learning				
		Speech Recognition Systems				
		Information Retrieval				
5	**Any one of the following Electives: (Minor Elective-II)**		4	3	1	0
	BCS 712	Computational Intelligence				
		Fundamentals of Generative AI				
		Introduction to Robotics				
		AI in Clinical Information Systems				
Total			**20**	**15**	**3**	**2**
Semester VIII						
1	BCS 801	Big Data Analytics	4	3	1	0
2	**Any one of the following Electives: (Major Elective-III)**		4	3	1	0
	BCS 802	Free Open-Source Software (FOSS)				
		Software Testing				
		Introduction to Wireless Sensor Networks				
3	BCS 811	Dissertation -II	12	0	0	12
Total			**20**	**6**	**2**	**12**

***L**: Lecture; **T**: Tutorial; **P**: Practical

IDE: Interdisciplinary Elective
AECC: Ability Enhancement Compulsory Course
SEC: Skill Enhancement Courses
VAC: Value-Added Courses
* **MOOCs**: Massive Open Online Course

Note:

1. MOOCs are chosen by the student based on the availability of the courses offered on SWAYAM platform.
2. The Programme template and the title of the courses are tentative, any changes as required may be made.

Credit Distribution

Semester	Total Credits	Cumulative Credit at the end of the Semester
I	22	22
II	22	44
III	21	65
IV	20	85
V	23	108
VI	24	132
VII	20	152
VIII	20	172

Assessment Pattern for Theory Courses: 40% of internal [formative evaluation – two best out of three tests (for a maximum of 15 marks each = 30 marks) and seminar/ assignments/attendance (10 marks)] and 60% (summative evaluation – end of the semester examination)

End Semester Examination

Maximum Marks: 60 Time: 3 Hours

Assessment Pattern for Theory with laboratory Courses: 60% of internal [formative evaluation – two best out of three tests (for a maximum of 15 marks each = 30 marks), practical lab (20 marks) and seminar/ assignments/attendance (10 marks)] and 40% (summative evaluation – end of the semester examination)

End Semester Examination

Maximum Marks: 40 Time: 2 Hours

Dissertation / Project Report

Dissertation Evaluation - 60 Marks Seminar and Viva-Voce- 40 Marks

Minimum Credit Requirements to Award Degree of B.Sc. (Hons) Computer Science & AI as per UGC Guidelines.

S. No	Broad Category of Course	Minimum Credit Requirement	
		3-year UG	**4-Year UG**
1.	Major (Core)	60	80
2.	Minor Stream	24	32
3.	Multidisciplinary	09	09
4.	Ability Enhancement Courses (AEC)	08	08
5.	Skill Enhancement Courses (SEC)	09	09
6.	Value Added Courses common for all UG	06-08	06-08
7.	Summer Internship	02-04	02-04
8.	Research Project / Dissertation	---	12
	Total	**120**	**160**

Important Information to Students

I. Programme: B.Sc. (Hons.) in Computer Science and Artificial Intelligence

II. Eligibility: A minimum of 50% marks in 10+2 with Mathematics as one of the optional subjects from any recognized board in India.

III. The minimum duration for completion of any UG Programme is eight semesters (four academic years) and the total duration for completing the programme shall not exceed 7 years or as per amendments made by the regulatory bodies from time to time.

IV. A student should attend at least 75% of the classes, seminars, practicals/ lab in each course of study.

V. All theory courses in the programme carry a Continuous Internal Assessment (CIA) component to a maximum of 40 marks and End Semester Examination (ESE) for a maximum of 60 marks. The minimum pass marks for a course is 40%.

VI. In case of courses with lab component Continuous Internal Assessment (CIA) component shall be of 60 marks and Semester-end component for 40 marks. The minimum pass marks for a course are 40%.

VII. The student is given three Continuous Internal Assessment (CIA) tests per semester in each course from which the best two performances are considered for the purpose of calculating the marks in CIA. A record of the continuous assessment is maintained by the academic unit. The three internal tests are conducted for 15 Marks each, out of which the best two tests' scores are considered for 30 marks. Out of the remaining 10 marks, 5 marks are awarded for assignments, class presentations and class participation of the students and the remaining 5 marks are awarded for punctuality, and attendance of the student.

Marks for the Attendance will be considered as follows:

S. No	Attendance (%)	Marks
1	95% or more	5
2	90-94%	4
3	85-89%	3
4	80-84%	2
5	75-79%	1

VIII. A student should pass separately in both CIA and the ESE, i.e., a student should secure 16 (40% of 40) out of 40 marks for theory in the CIA. A student should secure 24 (40% of 60) out of 60 marks for theory in the end semester examination (ESE).

IX. Semester-end examination shall consist of objective type questions, descriptive type questions and short answer questions or any other recommended by the BOS.

X. A student failing to secure the minimum pass marks in the CIA is not allowed to take the end semester examination of that course. She/he has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the end semester examination.

XI. Students failing a course due to lack of attendance should redo the course.

XII. Re-evaluation is applicable only for theory papers and shall not be entertained for other components such as practical/ thesis/ dissertation/ internship etc.

XIII. An on- campus elective course is offered only if a minimum of ten or 40% of the students registered, whichever is higher, exercise their option for that course.

SEMESTER-WISE DETAILED SYLLABUS

SEMESTER-I

Course Code : **BCS101** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **COMPUTER FUNDAMENTALS & PROGRAMMING IN C**

Course Objectives:

- To Understand the foundational concepts of computer systems, including hardware components, operating systems, and software development environments.
- To Gain proficiency in the C programming language, focusing on syntax, data types, control structures, and functions.
- To Develop problem-solving skills through practical programming exercises and projects, emphasizing algorithmic thinking and code optimization.
- To Learn the principles of structured programming and modular code design to create efficient and maintainable software solutions.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basic components and functions of a computer system, including hardware, software, and peripheral devices.
- Demonstrate proficiency in programming using the C language, including variables, loops, decision-making constructs, and functions.
- Develop problem-solving abilities by applying algorithmic thinking to design and implement solutions to programming challenges.
- Apply programming skills in various domains such as software development, system programming, or embedded systems.

Course Outline:

Unit-I **[11 hours]**

Introduction to Computers: Characteristics of Computers–Block diagram of computer. Types of computers and features–Types of Programming Languages. Data Organization, Drives, Files, Directories–Types of Memory (Primary and Secondary) RAM, ROM, PROM, EPROM. Secondary Storage Devices (FD, CD, HD, Pen drive) I/O Devices (Scanners, Plotters, LCD, Plasma Display)
Introduction to Algorithms and Programming Languages: Algorithm, Key Features of Algorithms– Some More Algorithms– Flow Charts, Pseudo Code–Programming Languages– Generation of Programming Languages – Structured Programming Language.

Unit-II **[16 hours]**

Introduction to C– Structure of C Program – Writing the First C Program –File Used in C Program – Compiling and Executing C Programs – Using Comments –Keywords – Identifiers – Basic Data Types in C – Variables – Constants – I/O Statements in C- Operators in C- Type Conversion and Type Casting

Unit-III **[16 hours]**

Introduction to Decision Control Statements –Conditional Branching Statements – Iterative Statements – Nested Loops – Break and Continue Statement – Goto Statement

Functions Introduction – Using functions – Function Declaration/ Prototype – Function Definition – Function Call – Return Statement – Passing Parameters – Scope of Variables –Storage Classes – Recursive Functions – Recursion vs Iteration.

Unit-I V **[16 hours]**

Introduction – Declaration of Arrays – Accessing Elements of The Array - Operations on Array – One Dimensional Array -Two Dimensional Arrays –Operations on Two Dimensional Arrays.
Strings Introduction –String Operations –Miscellaneous String and Character Functions

Unit-V **[16 hours]**

Pointers: Introduction to Pointers – declaring Pointer Variables– Pointer Expressions and Pointer Arithmetic - Passing Arguments to Functions using Pointer – Pointer and Arrays – Passing Array to Function - Dynamic Memory Allocation –Structure- Union- and Enumerated Data Types. Introduction to Files – Using Files in C – Reading Data from Files – Writing Data from Files.

Suggested Readings:

Reema Thareja- "Fundamentals of Computers," Oxford University Press, 2nd Edition, 2019

V. Rajaraman, "Fundamentals of Computers," PHI, 6th Edition, 2014

Reema Thareja, "*Introduction to C programming*," Oxford University Press, 2nd Edition, 2015.

E Balagurusamy, "*Computing Fundamentals & C Programming*", Tata McGraw-Hill, 2nd Edition 2015.

References:

Ashok N Kamthane, "*Programming with ANSI and Turbo C*," Pearson Education, 2002.

Henry Mullish & Huubert L.Cooper, "*The Spirit of C An Introduction to modern Programming*", Jaico Pub. House,1998.

Brian W. Kernighan / Dennis Ritchie ,"*The C Programming Language*", Pearson Education, 2nd Edition 2015

Anita Goel, "*Computing Fundamentals*," The world book ,1st Edition, January 2020

Course Code : **BCS102** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **DISCRETE MATHEMATICS**

Course Objectives:

- To understand foundational concepts to analyze mathematical structures.
- To apply algorithms in solving problems involving integers and modular arithmetic.
- To master techniques of mathematical induction, counting principles, and recurrence relations for solving combinatorial problems.
- To develop proficiency in matrix algebra, including determinants, eigenvalues, and solving linear systems of equations.
- To explore graph theory fundamentals to analyze and solve graph-related problems.

Learning Outcomes:

After completion of the course, students will be able to

- Identify and classify sets, relations, and functions, demonstrating comprehension through examples and definitions.
- Apply principles of mathematical induction and combinatorics to solve problems and prove results.
- Analyze and manipulate matrices, determinants, and systems of linear equations using appropriate techniques.
- Evaluate and apply graph theory concepts, including graph terminology, paths, cycles, and connectivity.

Course Outline:

Unit-I **[14 hours]**

Sets- Relations- Equivalence Relations- Partial Ordering- Well Ordering- Axiom of Choice- Zorn's Lemma- Functions- Cardinals- and Ordinals- Countable and Uncountable Sets- Statements- Compound Statements- Proofs in Mathematics- Truth Tables- Algebra of Propositions- Logical Arguments- Well-Ordering Property of Positive Integers.

Unit-II **[10 hours]**

Division Algorithm- Divisibility and Euclidean Algorithm- Congruence Relation between Integers- Modular Arithmetic- Chinese Remainder Theorem- Fermat's Little Theorem.

Unit-III **[12 hours]**

Principles of Mathematical Induction- Pigeonhole Principle- Principle of Inclusion and Exclusion Fundamental Theorem of Arithmetic- Permutation Combination- Circular Permutations Binomial and Multinomial Theorem- Recurrence Relations- Generating Functions- Generating Function from Recurrence Relations.

Unit-IV **[14 hours]**

Matrices- Algebra of Matrices- Determinants- Fundamental Properties- Minors and Cofactors- Product of Determinant- Adjoint and Inverse of a Matrix- Rank and Nullity of a Matrix- Systems of Linear Equations-

Row Reduction and Echelon Forms- Solution Sets of Linear Systems- Applications of Linear Systems- Eigen Values- Eigen Vectors of a Matrix.

Unit-V **[10 hours]**

Graph Terminology- Types of Graphs- Subgraphs- Isomorphic Graphs- Adjacency and Incidence Matrices- Paths- Cycles and Connectivity- Eulerian and Hamiltonian Paths- Planar Graphs.

Suggested Readings:

Kenneth Rosen, "Discrete Mathematics and Its Applications," Mc Graw Hill Education, 7th Edition, 2017.

References:

Edgar G. Goodaire and Michael M. Parmenter, "Discrete Mathematics with Graph Theory," Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

V Krishna Murthy, V. P. Mainra, J. L. Arora, "An Introduction to Linear Algebra," Affiliated East-West Press Pvt. Ltd.

Course Code : **BCS111** Course Type : **MINOR** No. of Credits : **4** No. of Hours : **60**	Course Title **FUNDAMENTALS OF AI AND APPLICATIONS**

Course Objectives:

- To Understand the fundamental concepts and history of artificial intelligence, components of AI programs, and its foundational principles.
- To Explore the various types of intelligent agents.
- To Learn different search strategies in AI.
- To Gain insights into knowledge representation in AI.
- To Explore real-world applications of AI

Learning Outcomes:

After completion of the course, students will be able to

- Remember the foundational concepts and historical developments in Artificial Intelligence.
- Understand the principles of intelligent agent design.
- Apply search strategies effectively, distinguishing between uninformed and informed methods to solve AI problems.
- Analyze different approaches to knowledge representation in AI.
- Evaluate the diverse applications of AI in various domains.

Course Outline:

Unit-I [10 hours]

Introduction to Artificial Intelligence: Introduction, Brief History- Intelligent Systems- Categorization of Intelligent Systems- Components of AI Program- Foundations of AI- Sub-areas of AI- Applications- Development of AI Languages- Current Trends in AI- Future of AI

Unit-II [10 hours]

Intelligent Agents: Rational Agents- Mapping from Sequences to Actions- Properties of Environments- Structure of Intelligent Agents- Types of Agents: Simple Reflex Agents- Goal Based Agents- Utility Based Agents.

Unit-III [14 hours]

Search Strategies: Uninformed Search Strategies-Breadth-First Search- Uniform Cost Search- Depth-First Search- Analysis of Search Methods- Informed Search Strategies: Heuristic Functions- Best-First Search- Greedy Search- A* Algorithm- Optimal Solution by A* Algorithm.

Unit-IV [14 hours]

AI – Knowledge Representation -Procedural versus Declarative Knowledge – Logic Programming – Forward Versus Backward Reasoning –Matching – Control Knowledge –Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories –Reasoning with Default Information.

Unit-V **[12hours]**

Applications of AI- Language Models – Information Retrieval- Information Extraction – Natural Language Processing – Machine Translation – Speech Recognition – Robot – Hardware –Perception

Suggested Readings:

Stuart Russel and Peter Norvig- *"Artificial Intelligence: A Modern Approach,"* Pearson Education, 3rd Edition, 2010.

E. Rich and K. Knight, "*Artificial Intelligence*," TMH, 3rd Edition, 2017.

References:

B. Yagna Narayana, "*Artificial Neural Networks*", PHI, 2005.

Dan W. Patterson, "*Artificial Intelligence and Expert Systems*," Pearson Education, 2018.

Joseph C. Giarrantano, Gary D. Riley, "*Expert Systems: Principles and Programming*," Course Technology Inc, 4th Edition, 2004.

Ivan Bratko, *"PROLOG Programming for Artificial Intelligence,"* Pearson, 4th Edition, 2011.

Course Code: **BCS113** Course Type: **AEC** Credits : **2** No. of Hours : **60**	Course Title **Human Rights and Duties**

Course Objectives:

- To gain a clear understanding of the human rights and duties.
- To learn the integral relationship between human rights and duties.
- To cultivate the art of appreciation of values- Freedom, Equality, Fraternity, Justice and respect for others.

Course Outcomes:

- Able to explain and apply the fundamental principles of human rights.
- Understand the relationship between rights and duties and their connection to moral, ethical, social and democratic values.
- Knowing the need to follow the duties and follow.

Unit-I: Human Rights- Meaning, Evolution, Significance. [15 hours]

Rights and Human Rights.
Claim Rights and Liberty Rights
Positive Rights and Negative Rights
Individual Rights and Group Rights
Universal Rights

Unit-II: Duties- Meaning, Significance, Necessity [15 hours]

Rights-Duties –Obligation
Duties-Natural and Acquired, Positive and Negative
Duties-Individual, Society and State-Impact
Duty as a Value and as a Life

Suggested Readings:

Donnelly, J. (2013). *Universal human rights in theory and practice* (3rd ed.). Cornell University Press.
Sharma, S. K., & Aggarwal, R. C. (2010). *Human rights and duties in India*. New Delhi: Prentice-Hall of India.

References:

Alston, P., & Goodman, R. (2013). International human rights. Oxford University Press.

Basu, D. D. (2012). Human rights in constitutional law. LexisNexis Butterworths Wadhwa.

Baxi, U. (2008). The future of human rights (3rd ed.). Oxford University Press.

Donnelly, J. (2013). Universal human rights in theory and practice (3rd ed.). Cornell University Press.

Government of India. (2023). The Constitution of India. Ministry of Law and Justice. https://legislative.gov.in/constitution-of-india

Course Code : **BCS114** Course Type : **SEC** No. of Credits : **3** No. of Hours : **45**	Course Title **MODERN ENGLISH GRAMMAR & PRONUNCIATION**

Course Objectives:

- To equip the student with the skills to use words appropriately
- To help the student develop insights into the structure of the English language
- To familiarize the student with the pronunciation of English

Learning Outcomes:

By the end of the course, the student

- will have learned to use contextually appropriate words.
- will have acquired basic knowledge of modern English grammar and usage.
- will have become familiar with English speech sounds and the basic aspects of word accent and intonation.

Course Outline:

Unit-I **[10 hours]**

Some Major Concepts and Categories-Verbs and Auxiliaries, The Semantics of the Verb Phrase

Unit-II **[12 hours]**

Word Formation, Derivation, Conversion, Compounding, Blending, Analogy, Abbreviation (Clipping, Acronyms, Initialisms), Phrasal Verbs, Collocation, Using the Dictionary: The Five S Approach, Nouns and Determiners, The Simple Sentence

Unit-III **[11 hours]**

The Speech Mechanism, English Vowels, English Consonants

Unit-IV **[12 hours]**

Word Accent, Phonological Environment: Weak Forms, Assimilation, Elision; Intonation

Suggested Readings:

Alan Cruttenden: Gimson's Pronunciation of English
John Wells: Longman Pronunciation Dictionary
M.J. Müller, N. Rutter, and B. Bryan Gick: Phonology for Communication Disorders
L. Colantoni, J. Steele, and P.R. Escudero Neyra: Second Language Speech: Theory and Practice

References:

Cambridge International Dictionary of Phrasal Verbs. Cambridge: CUP, 1997.
Greenbaum, Sidney, and Randolph Quirk. A Student's Grammar of the English Language. Harlow: Longman, 1990. (Chapters 2,3,4,5, and 10)
Jones, Daniel. English Pronouncing Dictionary (Latest Edition)
Leech, Geoffrey, and Jan Svartvik. A Communicative Grammar of English. 3rd Ed., Harlow: Pearson, 2002.
Sethi, J., and P.V. Dhamija. A Course in Phonetics and Spoken English. 2nd Ed., India: Prentice-Hall, 1999.
Swan, Michael. Practical English Usage. 3rd Ed., Oxford: OUP, 2005.
Yule, George. The Study of Language. 4th Ed., Cambridge: Cambridge University Press, 2010. (Chapter 5)

SEMESTER-II

Course Code : **BCS201** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **INTRODUCTION TO OOPs USING C++**

Course Objectives:

The objective of this course is to

- Understand the fundamental principles and concepts of Object-Oriented Programming
- Acquire proficiency in the basic syntax, structure, and elements of C++ programming.
- Master the concepts of classes and objects in C++
- Gain proficiency in utilizing inheritance and polymorphism in C++,
- Develop skills in exception handling and file input/output operations in C++

Learning Outcomes:

After completion of the course, students will be able to

- Differentiate object-oriented programming and procedural programming.
- Construct classes, functions, and objects
- Analyze the concept of inheritance in C++ distinguish between its various types
- Understand and implement the constructors, destructors, and inheritance.
- Develop programs using dynamic memory management techniques

Course Outline:

Unit-I **[12 hours]**

OOP Concepts: Abstraction- Encapsulation- Inheritance- Polymorphism- Procedural Vs. Object-Oriented Programming- Principles of OOP- and their benefits.

Unit-II **[16 hours]**

C++ Programming Basics: Program Structure and Basic Syntax in C++- Namespaces- Identifiers- Variables- Constants- Enums- Operators and Typecasting in C++.

Unit-III **[16 hours]**

Classes and Objects: Classes and Objects in C++- Access Specifiers: Public- Private- Protected- Constructors and Destructors in Classes.

Unit-IV **[16 hours]**

Inheritance and Polymorphism: Concept of Inheritance and its Types- Polymorphism and Function Overloading- Virtual Functions and Abstract Classes.

Unit-V **[15 hours]**

Introduction to Exception Handling: try-catch Blocks- Exception Propagation- File I/O Operations in C++.

Suggested Readings:

E. Balagurusamy- "*Object Oriented Programming with C++,"* TMH, 8th Edition, 2020.

B. Stroutstrup, "*The C++ Programming Language*", Pearson Education,4th Edition,2022.

References:

Herbert Schildt, "The Complete Reference C++," TMH, 4th Edition, 2017.

S. B. Lippman and J. Lajoie, "*C++ Primer*," Pearson Education, 5th Edition.

Course Code : **BCS202** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **WEB TECHNOLOGIES**

Course Objectives:

- To understand the fundamentals of HTML.
- To gain proficiency in Cascading Style Sheets to control the presentation and layout of HTML elements and create visually appealing web pages.
- To develop a strong foundation in JavaScript programming to enable the creation of interactive and dynamic web content.
- To learn advanced techniques in DHTML using JavaScript.
- Explore the principles and applications of XML for defining and structuring data in web applications.

Learning Outcomes:

After completion of the course, students will be able to

- Remember basic HTML elements and attributes for structuring web documents.
- Comprehend the principles of Cascading Style Sheets (CSS) and their application in styling web content.
- Demonstrate the ability to utilize JavaScript to create interactive web pages.

Course Outline:

Unit-I **[15 hours]**

HTML: Basic HTML- Document Body- Text- Hyperlinks- Adding More Formatting- Lists- Tables using Images. More HTML: Multimedia Objects- Frames- Forms Towards Interactive- HTML Document Heading.

Unit-II **[15 hours]**

Cascading Style Sheets: Introduction- Using Styles- Simple Examples- Your Own Styles- Properties and Values in Styles- Style Sheet- Formatting Blocks of Information- Layers.

Unit-III **[18 hours]**

Introduction To Javascript: What Is DHTML- Javascript- Basics- Variables- String Manipulations- Mathematical Functions- Statements- Operators- Arrays- Functions. Objects In Javascript: Data and Objects in Javascript- Regular Expressions- Exception Handling.

Unit-IV **[15 hours]**

DHTML with JavaScript: Data Validation- Opening A New Window- Messages and Confirmations- The Status Bar- Different Frames- Rollover Buttons- Moving Images.

Unit-V **[12 hours]**

XML: Defining Data for Web Applications- Basic XML- Document Type Definition- Presenting XML- Document Object Model. Web Services.

Suggested Readings:

Harvey M. Deitel and Paul J. Deitel- "*Internet & World Wide Web How to Program*," Pearson Education, 5th Edition, 2018.

Laura Lemay, Rafe Colburn, "Mastering HTML, CSS & JavaScript Web Publishing", BPB Publications, 1st Edition, 2016.

References:

Uttam K. Roy, "*Web Technologies*," Oxford University Press, 2010.

Godbole, Khate, "*Web Technologies*," McGraw Hill, 3rd Edition 2017.

Course Code : **BCS211** Course Type : **Minor** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO MACHINE LEARNING**

Course Objectives:

- To understand the fundamental concepts and types of learning in machine learning
- To evaluate the techniques for data analysis and pattern recognition.
- To implement distance-based clustering techniques.
- To build tree and rule-based models.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the fundamentals of machine learning.
- Implement popular machine learning algorithms.
- Acquire the ability to clean, preprocess, and transform raw data into a suitable format for machine learning models.
- Evaluate the performance of machine learning models
- Gain insights into real-world applications of machine learning across various domains.

Course Outline:

Unit-I **[12 hours]**

Introduction – Basic Definitions- Types of Learning: Unsupervised Learning – Reinforcement Learning – Supervised Learning – Learning A Class from Examples – Hypothesis Space and Inductive Bias- Vapnik-Chervonenkis (VC) Dimension – Probably Approximately Correct (PAC) Learning – Noise – Learning Multiple Classes – Model Selection and Generalization-Evaluation and Cross Validation

Unit-II **[12 hours]**

Linear Regression- Classification - Introduction to Decision Trees-Learning Decision Trees-Issues-Pruning-Overfitting-K-Nearest Neighbour-Feature Selection -Feature Reduction: Dimensionality Reduction – Subset Selection – Principal Component Analysis – Factor Analysis – Multidimensional Scaling – Linear Discriminant Analysis.

Unit-III **[12 hours]**

Bayesian Learning-Bayes Theorem-Maximum Likelihood-Bayes Optimal Classifier--Naïve Bayes Classifier-Clustering: – K Means Clustering – Hierarchical Clustering.

Unit-IV **[12 hours]**

Linear Discrimination – Linear Model – Geometry of The Linear Discriminant – Pairwise Separation – Gradient Descent – Logistic Regression –Multilayer Perceptrons: Introduction – Perceptron – Training A Perceptron – Learning Boolean Functions – Multilayer Perceptrons – Backpropagation Algorithm.

Unit-V **[12 hours]**

Kernel Machines – SVM-Optimal Separating Hyperplane – Kernel Trick – Evaluation-Model Selection – Introduction to Ensembles- Bagging – Boosting. Applications Of Machine Learning

Suggested Readings:

Ethem Alpaydin*, "Introduction to Machine Learning,"* MIT Press, 4th Edition, 2020.

Andreas Mulle, *"Introduction to Machine Learning with Python", O'Reilly, 1st Edition 2016.*

References:

Tom M. Mitchell, *"Machine Learning," Mc* Graw Hill Education,1st Edition, 2017.

Chirag Shah, "*A Hands-On Introduction to Machine Learning*," Cambridge University Press, 2022.

Course Code : **BCS213** Course Type : **AEC** No. of Credits : 2 No. of Hours : **30**	Course Title **UNDERSTANDING DISABILITIES**

Course Objectives:

- To introduce the concept of disability, causes and measures to handle disabilities.
- To disseminate the spirit of Acts and policies in dealing with disabilities.

Learning Outcomes:

- Appreciate and accept the uniqueness of persons with disabilities and recognize their significance in society.
- Demonstrate the ability to empathize with fellow students and others with disability through knowledge about the related Acts.

Course Outline

Unit I **[15 hours]**

Introduction: Disabilities: Definitions and Classifications–Types and Causes of Disabilities: Physical, Sensory (visual, hearing), Cognitive and Intellectual, Developmental (Autism, Down Syndrome) and Mental Health. Impact of Disabilities: Individual Experiences, Family Dynamics and Care Giving, Social Isolation and Stigma, Employment and Economic Disparities.

Unit II **[15 hours]**

Accessibility and Inclusion: Accessibility in the Built Environment and Assistive Technologies – Disability Rights and the UN Convention on the Rights of Persons with Disabilities (CRPD) – The Rights of Persons with Disabilities (RPwD) Act, 2016 – National Education Policy 2020 (NEP 2020)

Suggested Readings:

Dell Orto, A. E., & Power, P. W. (2007). The psychological & social impact of illness and disability. Springer.

Hilton, A., & Ringlaben, R. (1998). Best and Promising Practices in Developmental Disabilities. Austin, TX: PRO-ED.

National Education Policy 2020, Government of India, Ministry of Education.

Panda, K. C. (1999). Education of exceptional children. Vikas Publishing House, New Delhi.

Schwean, V. L., & Saklofske, D. H. (Eds.). (1999). Handbook of psychosocial characteristics of exceptional children. Springer Science & Business Media.

The Rights of Persons with Disabilities (RPwD) Act, 2016.

References:

Ghai, A. (2018). Disability in South Asia: knowledge and experience. Sage.

Hegarty, S., & Alur, M. (Eds.). (2002). Education & children with special needs: From segregation to inclusion. Sage

Madhavan, T., Kalyan, M., Naidu, S., Peshawaria, R., & Narayan, J. (1989). Mental retardation:a manual for psychologists. Secunderabad: National Institute for the Mentally Handicapped.

World Health Organization. Disability. https://www.who.int/health-topics/disability

Course Code : **BCS214** Course Type : **SEC** No. of Credits : **3** No. of Hours : **45**	Course Title **ACADEMIC WRITING**

Course Objectives:

- To help the student build their argument in their academic writing
- To enable the student to acquire the ability to use both descriptive and critical rhetoricalfunctions in their academic writing
- To enhance the ability of the student to legitimately borrow ideas from other scholars with appropriate discipline-specific citation practices and articulate their own voice while reviewing others' works

Learning Outcomes:

By the end of the course the student

- will have acquired the ability to use both descriptive and critical rhetorical functions intheir academic writing.
- will have enhanced their ability to integrate material from a range of sources.
- will be able to develop their argument in their academic writing.

Course Outline:

Unit- I **[15 hours]**

Rhetorical Functions in Academic Writing: Introduction – Defining terms and ideas–Describing– Comparing and contrasting–Classifying– Explaining causes and effects.

Moving from Description to Analysis: Description vs Analysis – Analysis vs Synthesis – Process of analyzing information – Strategies of organizing information.

Developing Arguments

Unit- II **[15 hours]**

Developing Paragraphs in Academic Writing: Elements of an academic paragraph: MEAL - Main idea (Lead in) – Evidence-Analysis-Lead Out-Functions of topic stage-Functions of body stage-Functions of conclusion

Unit- III **[15 hours]**

Information Structure**:** Theme – Rheme/Given – New/Topic – Comment; Elements that constitute themes-Information packaging patterns- Linear theme - Zigzag theme - Multiple themes.

Source Use: Evaluating Different Sources **-** Source Use Strategies**-** Paraphrasing**-** Summarising **-** Direct Quoting - Functions of Citation - Use of Reporting Verbs - Finding One's Voice

References:

Gillett, A., Angela, H., and Mary Martala. *Inside Track: Successful Academic Writing.* Essex: Pearson Education Limited, 2009.

Murray and Geraldine Hughes. *Writing up your University Assignments and Research Projects: A Practical Handbook.* New York: Open University Press, 2008.

Swales, J. M., and C. B. Feak. *Academic Writing for Graduate Students: A Course for Non-native Speakers of English.* Ann Arbor: University of Michigan Press, 1994.

Yakhontova, T. *English Academic Writing for Students and Researchers*. Lviv: PAIS, 2003.

Wallwork. *English for Academic Research: Writing Exercises*. New York: Springer, 2013.

Course Code : **BCS 215** Corse Type : **VAC** No. of Credits : **2** No. of Hours : **30**	Course Title **ECOLOGY AND ENVIRONMENT**

Course Objectives:

- To introduce the multidisciplinary nature of environment and its constituents.
- To sensitize on environment related issues and its conservation

Learning Outcomes:

- Gain insights into various environmental initiatives and related legislations.
- Disseminate about the significance of environment management and conservation.

Course Outline:

Unit- I **[15 hours]**

Ecology and Ecosystem: Environment. - Biosphere. - Ecology. - Ecosystem. - Biodiversity: Hot Spots, Causes and Effects of Loss of Biodiversity - Biodiversity Conservation and Species-Based Conservation Programmes (Project Tiger, Project Elephant, Project Snow Leopard, and others).

Unit- II **[15 hours]**

Pollution, Degradation and Conservation: Meaning and Types of Pollution (Land, Air and Water Pollution) - Land Degradation, Desertification and Sustainable Land Management (SLM) - Environmental Governance: Institutional bodies, Legislations and Conventions (National and International).

Suggested Readings:

Bhargava.; Olson, Keith; Rajaram, V.; Tiede, Lynn (2019). Ecology and environment. Chapman and Hall/CRC.

Anubha Kaushik (2010). Basics of environment and ecology. New Age International Ltd.

References:

Vesilind, P. A., Peirce, J. J., & Weiner, R. F. (2013). Environmental pollution and control. Elsevier.

Alberts, R. C., Retief, F. P., Cilliers, D. P., Roos, C., & Hauptfleisch, M. (2021). Environmental impact assessment (EIA) effectiveness in protected areas. Impact Assessment and Project Appraisal, 39(4), 290–303.

SEMESTER-III

Course Code : **BCS301** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **INTRODUCTION TO JAVA PROGRAMMING**

Course Objectives:

- To understand object-oriented programming concepts, and apply them in solving problems.
- To introduce the principles of inheritance and polymorphism; and demonstrate how they relate to the design of abstract classes

Learning Outcomes:

After completion of the course, students will be able to

- Understand the use of oops concepts.
- Solve real world problems using OOP techniques.
- Analyze and debug Java code to identify and fix errors, demonstrating problem-solving skills.

Course Outline:

Unit-I **[16 hours]**

Fundamentals of Object – Oriented Programming: Introduction- Object-Oriented Paradigm- Basic Concepts of OOP- Benefits of OOP- Applications Of OOP- Java Features: Overview of Java Language: Introduction- Simple Java Program Structure- Java Tokens- Java Statements- Implementing A Java Program- Java Virtual Machine- Command Line Arguments. Constants- Variables & Data Types: Introduction- Constants- Variables- Data Types- Declaration of Variables- Giving Value to Variables- Scope of Variables- Symbolic Constants- Type Casting- Getting Value of Variables- Standard Default Values; Operators & Expressions.

Unit-II **[16 hours]**

Decision Making & Branching: Introduction- Decision Making with if Statement- Simple if Statement, if. Else Statement- Nesting of if else Statements- The else if Ladder- The switch Statement- The conditional Operator.
Looping: Introduction- The while Statement- The do-while Statement- The for Statement- Jumps in Loops.
Classes- Objects & Methods: Introduction- Defining A Class- Adding Variables- Adding Methods- Creating Objects- Accessing Class Members- Constructors- Method Overloading- Static Members- Nesting of Methods.

Unit-III **[16 hours]**

Inheritance: Extending A Class- Overloading Methods- Final Variables and Methods- Final Classes- Abstract Methods and Classes;
Arrays- Strings and Vectors: Arrays- One-Dimensional Arrays- Creating an Array- Two – Dimensional Arrays- Strings- Vectors- Wrapper Classes;
Interfaces: Multiple Inheritance: Introduction- Defining Interfaces- Extending Interfaces- Implementing Interfaces- Assessing Interface Variables;

Unit-IV **[15 hours]**

Multithreaded Programming: Introduction- Creating Threads- Extending the Threads- Stopping and Blocking a Thread- Lifecycle of a Thread- Using Thread Methods- Thread Exceptions- Thread Priority- Synchronization- Implementing the 'Runnable' Interface.

Managing Errors and Exceptions: Types of Errors: Compile-Time Errors- Run-Time Errors- Exceptions- Exception Handling- Multiple Catch Statements- Using Finally Statement.

Unit-V **[12 hours]**

Packages: Introduction- Java API Packages- Using System Packages- Naming Conventions- Creating Packages- Accessing a Package- Using a Package.

Suggested Readings:

E. Balaguruswamy, "*Programming with JAVA*," McGraw-Hill, 2023.
Herbert Schildt, "*Java: The Complete Reference*," McGraw-Hill, 13th Edition, 2024

References:

John R. Hubbard, "*Programming with Java*- Schaum's outline Series", McGraw-Hill, 2nd Edition, 2020
Deitel &Deitel. "*Java ™: How to Program*," PHI, 6th Edition, 2020.
R. Nageswara Rao, "*Core Java: An Integrated Approach*," Dreamtech Press, 2016.

Course Code : **BCS302** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **COMPUTER ORGANIZATION AND ARCHITECTURE**

Course Objectives:

- To introduce the fundamental principles and concepts of computer organization, architecture, and digital electronics.
- To provide solid understanding of how computers are designed and how digital circuits operate, enabling them to comprehend the interactions between hardware and software components.

Learning Outcomes:

After completion of the course student will be able to:

- Understand various components of computer and their interconnection
- Understand basic components and design of the C.P.U
- Compare and select various Memory devices as per requirement.
- Compare various types of IO mapping techniques.

Course Outline:

Unit I **[15 hours]**

Structure of Computers: Computer Types- Functional Units- Basic Operational Concepts- Von Neumann Architecture- Bus Structures- Software- Performance- Multiprocessors and Multicomputer- Data Representation- Fixed and Floating Point- Error Detection and Correction Codes.

Computer Arithmetic: Addition and Subtraction- Multiplication and Division Algorithms- Floating-Point Arithmetic Operations- Decimal Arithmetic Operations

Unit II **[15 hours]**

Basic Computer Organization and Design: Instruction Codes- Computer Registers- Computer Instructions and Instruction Cycle. Timing And Control- Memory-Reference Instructions- Input-Output and Interrupt. Central Processing Unit: Stack Organization- Instruction Formats- Addressing Modes- Data Transfer and Manipulation- Complex Instruction Set Computer (CISC) Reduced Instruction Set Computer (RISC)- CISC Vs RISC

Unit III **[15 hours]**

Register Transfer and Micro-Operations: Register Transfer Language- Register Transfer- Bus and Memory Transfers- Arithmetic Micro-Operations- Logic Micro-Operations- Shift Micro-Operations- Arithmetic Logic Shift Unit. MICRO-PROGRAMMED CONTROL: Control Memory- Address Sequencing- Micro-Program Example- Design of Control Unit.

Unit IV **[15 hours]**

Memory System: Memory Hierarchy- Semiconductor Memories- RAM (Random Access Memory)- Read Only Memory (ROM)- Types Of ROM- Cache Memory- Performance Considerations- Virtual Memory- Paging- Secondary Storage- RAID.

Unit V **[15 hours]**

Input Output: I/O Interface- Programmed IO- Memory Mapped IO- Interrupt Driven IO- DMA. Multiprocessors: Characteristics Of Multiprocessors- Interconnection Structures- Inter Processor Arbitration- Inter Processor Communication and Synchronization- Cache Coherence.

Suggested Readings*:*

M. Moris Mano, "*Computer System Architecture*", Pearson, 3rd Edition, 2017.
Carl Hamacher, Zvonks Vranesic, SafeaZaky, "*Computer Organization*," McGraw Hill, 5th Edition, 2017.

References:

William Stallings, "*Computer Organization and Architecture- Designing for Performance*," Pearson Education, 10th Edition, 2016.
Anrew S. Tanenbaum, "*Structured Computer Organization*," Pearson Education, 6th Edition,2016.
John P. Hayes, "*Computer Architecture and Organization*," McGraw-Hill, 3rd Edition, 2017.

Course Code : **BCS311** Course Type : **MINOR** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO DEEP LEARNING**

Course Objectives:

- To acquire the basic concepts and principles of deep learning, including neural networks and their architectures.
- To apply deep learning techniques to solve real-world problems, such as image classification or natural language processing tasks.
- To evaluate the performance and effectiveness of deep learning models using appropriate metrics and validation techniques.

Course Outcomes:

After completion of the course student will be able to:

- Understand the principles and structures underlying deep neural networks.
- Develop and train deep neural networks utilizing suitable frameworks and libraries.
- Implement deep learning methodologies to address practical challenges across diverse fields.
- Assess and refine deep learning models to enhance their efficiency and precision.
- Explore the deep learning applications.

Course Outline:

Unit I **[12 hours]**

Introduction to Deep Learning - Overview of Deep Learning Concepts and Its Significance - Basics of Neural Networks and Gradient-Based Optimization - Activation Functions and Loss Functions in Deep Learning.

Unit II **[12 hours]**

Convolution Neural Network – Feature Selection – Max Pooling - Filters and Feature Maps– Convolution Layer –Applications

Unit III **[12 hours]**

Recurrent Neural Network – Memory Cells – Sequence Analysis – Word2vec- LSTM — Memory Augmented Neural Networks – NTM—Applications

Unit IV **[12 hours]**

Tensor Flow – Variables – Operations – Placeholders – Sessions – Sharing Variables – Graphs – Visualization

Unit V **[12 hours]**

Applications of Deep Learning-Deep Learning for Image Classification and Object Detection - NLP and Sentiment Analysis with Deep Learning - Deep Learning in Recommendation Systems and Autonomous Vehicles.

Suggested Readings:

Nikhil Buduma, Nicholas Locascio, "*Fundamentals of Deep Learning: Designing Next- Generation Machine Intelligence Algorithms*", O'Reilly Media, 1st Edition, 2017.

Ian Goodfellow, Yoshua Bengio, Aaron Courville, "*Deep Learning (Adaptive computation and Machine Learning series)*", MIT Press, 2017.

References:

Francois Chollet, "*Deep Learning with Python*", Manning Publishers, 1st Edition, 2017.
John D. Kelleher, "Deep Learning", The MIT Press Essential Knowledge Series, 2019.

Course Code : **BCS313** Course Type : **AEC** No. of Credits : **2** No. of Hours : **30**	Course Title **Understanding Indian Economy**

Course Objectives:

- To familiarize students with the structure and functioning of the Indian economy.
- To provide an understanding of key sectors, policies, and challenges in India's economic development.
- To enable critical analysis of contemporary issues in the Indian Economy.

Learning Outcomes:

- Explain the historical and structural features of the Indian economy.
- Analyze sectoral contributions (agriculture, industry, services) to growth and development.
- Evaluate government policies and reforms in relation to inclusive and sustainable development. 4
- Critically discuss current challenges such as unemployment, poverty, and inequality.

Course Outline

Unit I **[15 hours]**

Structure and Growth of Indian Economy: Basic Features of the Indian economy – demographic profile, natural resources, dualism, and structural changes since independence. National Income – concepts, trends, and growth performance. Economic Reforms – Liberalization, Privatization, Globalization (LPG model) and their impact. Poverty, Unemployment, and Inequality – trends, measurement, and policy responses.

Unit II **[15 hours]**

Sectoral and Contemporary Issues: Agricultural Sector – role in Indian economy, problems, and policies (Green Revolution, MSP, recent reforms). Industrial Sector – MSMEs, industrial policies, role of Public Sector Enterprises, and Make in India. Service Sector – IT, trade, banking, tourism, health, and education. Current Issues – digital economy, sustainable development, climate change, globalization, and regional disparities.

Suggested Readings:

1. Dutt, R. & Sundaram, K.P.M. – Indian Economy
2. Mishra, S.K. & Puri, V.K. – Indian Economy: Its Development Experience
3. Uma Kapila – Indian Economy: Performance and Policies
4. Government of India – Economic Survey (latest edition)
5. Government of India – Union Budget (latest edition)

Course Code : **BCS314** Course Type : **SEC** No. of Credits : **4** No. of Hours : **75**	Course Title **INTRODUCTION TO PYTHON PROGRAMMING**

Course Objectives:

- To Gain familiarity with Python syntax, data types, and control structures to write simple programs.
- To Apply Python to solve computational problems, manipulate data, and automate tasks effectively.
- To Develop proficiency in writing Python scripts and programs for various applications, such as web development, data analysis, and automation**.**

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basics of programming language.
- Develop algorithmic solutions to simple computational problems
- Apply suitable programming constructs and built-in data structures to solve a problem

Course Outline:

Unit I **[16 hours]**

Introduction to Python Programming: Features/Characteristic of Python - Basic Syntax - Basic Data Types - Simple Input-Output - Precedence of Operators - Type Conversion - Conditional Statements - Looping: for, while, Nested Loops; Terminating Loops - Skipping Specific Conditions - Scope and Extent of Variables - Testing and Debugging Principles.

Unit II **[16 hours]**

Strings & Lists: Concept - Escape Characters - String Special Operations - String Formatting Operator - Single Quotes - Double Quotes - Triple Quotes - Raw String - Unicode Strings - Built-in String Methods - List Type Built-in Methods - Special Features of Lists.

Unit III **[16 hours]**

Tuples, Dictionaries & Functions: Tuples - Tuple Operators and Built-in Functions - Special Features of Tuples - Dictionaries, Operators, Built-in Functions, Built-in Methods, Dictionary Keys - Functions - Calling Functions - Creating Functions - Formal Arguments - Positional Arguments - Default Arguments - Variable-Length Arguments.

Unit IV **[12 hours]**

Object Oriented Programming Introduction to Classes, Objects and Methods; Standard Libraries

Unit V **[15 hours]**

Files and Input/Output: File Objects - File Built-in Function - File Built-in Methods - File Built-in Attributes - Standard Files - Command-Line Arguments - File System - File Execution - Persistent Storage Modules.

Suggested Readings:

Hetland, Magnus Lie, *"Beginning Python from Novice to Professional,"* Apress, 2nd Edition, 2017.

Lutz, M., *"Learning Python: Powerful Object-Oriented Programming,"* O'Reilly Media, Inc. 5th Edition, *2013.*

References:

FabeoNelli, *"Python Data Analytics,"* Apress, 2nd Edition, 2018.

Paul Barry, *"Head first Python: A Brain-Friendly Guide,"* O'Reilly Media, Inc., 2nd, 2016.

SEMESTER-IV

Course Code : **BCS401** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **OPERATING SYSTEMS**

Course Objectives:

- To introduce the structure and organization of a file system.
- To make aware of various functions of an operating system like memory management, process management, device management, etc.

Learning Outcomes:

After completion of the course, students will be able to

- Understand working of various Operating Systems and their services.
- Evaluate process scheduling algorithms, synchronization techniques and protection of an Operating System.
- Understand problems arising due to concurrency and related synchronization-based solutions.
- Apply the knowledge of methods to prevent and recover from a system deadlock.

Course Outline:

Unit-I **[14 hours]**

Operating Systems – Definitions – Functions – Types of Operating System – Multiprogramming– Batch, Time Sharing – Single User and Multiuser– Components – Operating System Services– System Calls – Programs – System Structure.

Unit –II **[16 hours]**

Process Management: Process Concepts– Process State & Process Control Block– Process Scheduling – Scheduling Criteria– Scheduling Algorithms– Multiple Processor Scheduling– Real-Time Scheduling – Threads.

Unit –III **[15 hours]**

Critical Section Problem: Semaphores– Classical Problem of Synchronization– Deadlock Characterizations– Method for Handling Deadlocks– Deadlock Prevention– Deadlock Avoidance– Deadlock Detection and Recovery

Unit –IV **[16 hours]**

Memory Management: Logical Versus Physical Address Space– Contiguous Allocation– Fixed Partition– Variable Partition– Swapping–Paging– Segmentation–Virtual Memory– Demand Paging– Page Replacement Algorithms.

Unit –V **[14 hours]**

Disk Scheduling: Disk Management–Swap Space Management– Disk Reliability– Stable Storage Implementation. File Concepts– Directory Structure, And Protection.

Suggested Readings:

Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, "*Operating System Concepts*," Wiley-India, 10th Edition, 2018.

References:

Andrew S. Tanenbaum, "*Modern Operating Systems,"* PHI, 5th Edition, 2022.
Elmasri, Carrick, Levine, "*Operating Systems: A Spiral Approach,"* TMH, 2010.

Course Code : **BCS402** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **FUNDAMENTALS OF DATA STRUCTURES**

Course Objectives:

- To organize data for more efficient problem-solving using data structure's methods and techniques.
- To impart the basic concepts of data structures and algorithms
- To be familiar with writing recursive methods.
- To understand concepts about searching, sorting techniques, stacks, and queues.

Learning Outcomes:

After completion of the course, students will be able to

- Demonstrate the different types of data structures
- Understand the concept of recursive algorithms.
- Able to understand the operations on linear data structures.
- Summarize searching and sorting techniques.
- Comprehend Data Structure and Their real-time applications- Stack, Queue, Trees, and Graphs.

Course Outline:

Unit I **[15 hours]**

Concept of Abstract Data Types (ADTs): Data Types, Data Structures– Storage Structures and File Structures– Primitive and Non-primitive Data Structures– Linear and Non-linear Data Structures. Linear Lists: ADT– Array and Linked Representations, Linked Lists: Single, Double, Circular Linked List, Applications.

Unit II **[15 hours]**

Stacks: Array and Linked representations– Implementations– Evaluation of Arithmetic Expression using Stack-Prefix –Infix-Postfix-Notations– Converting Infix Expressions to Postfix– Towers of Hanoi Problem.

Queues: Array and Linked Representations– Circular Queues– Dequeues– Priority Queues– Implementations and Applications.

Unit III **[15 hours]**

Trees: Binary Tree, Properties, Array and Linked representations– Binary Tree Traversals, Implementations and Applications. Binary Search Trees (BST) –Operations and Implementations– BST Applications.

Unit IV **[15 hours]**

Graphs: Graph and its Representation– Graph Traversals– Connected Components– Basic Searching Techniques – Minimal Spanning Tree- The Shortest Path Algorithm.

Unit- V **[15 hours]**

Sorting and Searching: Selection, Insertion, Bubble, Merge, Quick, Heap Sort, Sequential & Binary Searching.

Suggested Readings:

Samanta D, "*Classic Data Structures*," Prentice-Hall of India, 2nd Edition, 2023.

Sahni S, *"Data Structures, Algorithms and Applications in C++,"* McGraw-Hill, 2016

References:

D S Malik, "*Data Structures Using C++,"* Cengage, 2012.

Heilman G I, "*Data Structures and Algorithms with Object-Oriented Programming,"* Tata McGraw-Hill. 2002.

Jean-Paul Tremblay, and Paul G. Sorenson, "An Introduction to Data Structures with Applications," Tata McGraw-Hill, 2nd Edition, 2017.

Course Code : **BCS411** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **NATURAL LANGUAGE PROCESSING**

Course Objectives:

- To acquire fundamental knowledge of natural language processing.
- To comprehend methods for assessing the effectiveness of algorithms or systems.
- To familiarize oneself with the linguistic aspects pertaining to computer-human interactions.

Learning Outcomes:

After completion of the course, students will be able to

- Understand NLP challenges and conduct comprehensive literature reviews on specific problems.
- Comprehend language modeling concepts.
- Explain automated natural language generation and machine translation.
- Acquire proficiency in natural language generation techniques.

Course Outline:

Unit I **[12 hours]**

Overview and Language Modelling: Origins and Challenges of NLP Language and Grammar-Processing Indian Languages- NLP Applications Information Retrieval. Language Modeling: Various Grammar- Based Language Models-Statistical Language Model.

Unit II **[12 hours]**

Word Level Analysis- Unsmoothed N-Grams– Evaluating N-Grams– Smoothing– Interpolation and Backoff – Word Classes– Part-Of-Speech Tagging– Rule-Based– Stochastic and Transformation-Based Tagging– Issues in Pos Tagging – Hidden Markov and Maximum Entropy Models.

Unit III **[12 hours]**

Syntactic Analysis: Context-Free Grammars – Grammar Rules for English – Treebanks – Normal Forms for Grammar – Dependency Grammar – Syntactic Parsing – Ambiguity– Dynamic Programming Parsing – Shallow Parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGS – Feature Structures, Unification of Feature Structures.

Unit IV **[12 hours]**

Information Retrieval and Lexical Resources: Information Retrieval: Design Features of Information Retrieval Systems-Classical, Non-Classical, Alternative Models of Information Retrieval – Valuation Lexical Resources: World Net-Frame Net- Stemmers-POS Tagger- Research Corpora.

Unit V **[12 hours]**

Discourse Analysis and Lexical Resources: Discourse Segmentation – Coherence – Reference Phenomena – Anaphora Resolution Using Hobbs and Centering Algorithm – Coreference Resolution – Resources: Porter Stemmer – Lemmatizer – Penn Treebank – Brills Tagger – Wordnet – Propbank – Framenet – Brown Corpus – British National Corpus (BNC).

Suggested Readings:

Daniel Jurafsky, James H. Martin, "*Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech*", Pearson Publication, 2nd Edition, 2014.

References:

Nitin Indurkhya and Fred J. Damerau, "*Handbook of Natural Language Processing*", CRC Press, 2nd Edition, 2010.

Richard M Reese, "*Natural Language Processing with Java*," OReilly Media, 2015.

Course Code : **BCS412** Course Type : **AEC** No. of Credits : **4** No. of Hours : **60**	Course Title **BUILDING MATHEMATICAL ABILITY AND FINANCIAL LITERACY**

Course Objectives:

- Introduce fundamental mathematics and finance concepts to undergraduates.
- Develop proficiency in mathematical operations, logical reasoning, and financial instrument understanding.

Learning Outcomes:

- Apply fundamental mathematical concepts and logical reasoning to problem-solving.
- Demonstrate competency in handling financial instruments and analyzing data for informed decision-making.

Course Outline:

Unit I **[15 hours]**

Mathematics Fundamentals: Basic set theory - Permutations and combinations - Introduction to mathematical logic: propositions - truth values - logical connectives – tautology – contradiction - logical equivalences - conditional statements.

Unit II **[15 hours]**

Financial Mathematics: Cost price - selling price - profit, and loss - Simple interest - compound interest (reducing balance and flat rate) - Introduction to stocks and shares - Housing loans – insurance - Equated Monthly Installments (EMI) calculation - Basic Income Tax Calculations.

Unit III **[15 hours]**

Statistical Analysis: Sources of data: primary and secondary - Types of data and graphical representation Measures of central tendency: mean – median - mode - Measures of dispersion: rangevariance - standard deviation - coefficient of variation - Bivariate data analysis: scatter plot, correlation coefficient, simple linear regression.

Unit IV **[15 hours]**

Financial Literacy: Definition and functions of money - Role of banks - credit creation, and usage of debit and credit cards - Functions of central banks - with a focus on the Reserve Bank of India Monetary policy tools: bank rate policy - cash reserve ratio - open market operations, statutory liquidity ratio - repo rate - reverse repo rate - selective credit control.

Suggested Readings:

J. Medhi, "Statistical Methods: An Introductory Text," Wiley Eastern Ltd. (latest edition).
"Building Mathematical Ability," Foundation Course, University of Delhi, S. Chand Publications.
M.K. Lewis and P.D., "Monetary Economics," Oxford University Press, New York, 2000.

References:

C. Rangarajan, "Indian Economy: Essays in Money and Finance," 1999.
B. Brahmaiah and P. Subbarao, "Financial Futures and Options," Himalaya Publishing House, Mumbai, 1998.

Course Code : **BCS414** Course Type : **Core** No. of Credits : **2**	Course Title **Summer Internship Project**

The Summer Internship Programme (SIP) is a 2-credit course with a duration of 4 to 6 weeks of hands-on, practical experience during the summer vacation (approximately May-June) after the 4th semester. This internship aims to bridge the gap between theoretical learning and real-world application by immersing students in projects that utilize computer science and AI concepts. Students gain invaluable experience in areas such as software development, data analysis, AI applications, and system administration.

Students are required to submit an internship report detailing their tasks and the skills acquired, along with a certificate from the host organization. Additionally, they must present their report in a seminar before the department faculty for evaluation. The programme is assessed through the internship report (60 marks) and a Viva-Voce (40 marks) conducted by the department, adhering to the University's regulations. This comprehensive evaluation ensures that students are well-prepared for future career opportunities in computer science and AI.

SEMESTER-V

Course Code : **BCS501** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **DATABASE MANAGEMENT SYSTEMS**

Course Objectives:

- To understand database fundamentals, advantages of DBMS, and the three-schema architecture.
- To learn database design using the Entity-Relationship Model, covering entities, relationships, and constraints.
- To gain expertise in relational database concepts, algebra operations, and normalization for effective design.
- To acquire practical skills in SQL and PL/SQL for data manipulation, querying, and procedural logic implementation.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the characteristics and advantages of the database approach.
- Describe and utilize Entity-Relationship Models (ERMs) for database design.
- Apply the concepts of the Relational Model and Relational Algebra for database schema design.
- Demonstrate proficiency in Structured Query Language.

Course Outline:

Unit I **[12 hours]**

Introduction: Characteristics of Database Approach – Advantages of Using DBMS Approach – Data Models, Schemas, and Instances – Three Schema Architecture – Database Languages and Interfaces – The Database System Environment- Centralized and Client-Server Architectures.

Unit II **[15 hours]**

Entity-Relationship Model: Using High-Level Conceptual Data Models for Database Design – Entity Types, Entity Sets, Attributes and Keys – Relationship Types Relationship Sets, Roles**,** and Structural Constraints –Weak Entity Types – Refining the ER Design and Design Issues. Enhanced Entity-Relationship Model (EER Model), Generalization and Specialization.

Unit III **[18 hours]**

Relational Model and Relational Algebra: Relational Model Constraints and Database Schemas - Update Operations - Unary and Binary Relational Operations - Relational Algebra Operations from Set Theory - Relational Database Design Using ER to Relational Mapping- Database Design – Normal Forms Based on Primary Keys- Second and Third Normal Forms.

Unit IV **[15 hours]**

Structured Query Language: Introduction, History of SQL Standard – Commands in SQL – Data Types in SQL – Data Definition Language – Selection Operation, Projection Operation – Aggregate Functions – Data Manipulation Language – Table Modification Commands – Table Truncation – Imposition of Constraints – Join Operation – Set Operations – Views – Sub Query– Embedded SQL.

Unit V **[15 hours]**

PL/SQL: Introduction, Shortcoming in SQL – Structure of PL/SQL – PL/SQL Language Elements – Data Types –

Operators Precedence – Control Structure – Steps To Create A PL/SQL Program – Iterative Control – Cursors – Procedure –Function – Database Triggers.

Suggested Readings:

Abraham Silberschatz, Henry Korth, and S. Sudarshan, "*Database System Concepts*," McGraw-Hill, 7th Edition, 2019.

References:

R. Elmasri and S. Navathe, "*Fundamentals of Database Systems*", Pearson Education, 7th Edition, 2016.

Raghu Ramakrishnan, "Database Management Systems", McGraw-Hill, 3rd Edition, 2014.

C.J. Date, A. Kannan, S. Swaminathan, *"An Introduction to Database Systems"*, Pearson Education, 8th Edition, 2006

Course Code : **BCS502** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **FUNDAMENTALS OF DATA SCIENCE USING PYTHON**

Course Objectives:

- To provide the knowledge and skills of both the data sciences and python programming
- To obtain a comprehensive knowledge of various tools and techniques for data transformation and visualization.
- To learn how to describe the data for the data science process

Learning Outcomes:

After completion of the course, students will be able to

- Explore various steps of data science pipeline with role of Python.
- Acquire proficiency in Python basics and data structures.
- Develop skills in applying Python to Data Science tasks
- Use various data visualization tools for effective interpretations and insights of data.

Course Outline:

Unit I **[12 hours]**

Overview of the Data Science Process: Philosophies of Data Science - Data All Around Us - Data Science in a Big Data World - Benefits and Uses of Data Science - Facts of Data - Data Science Processes - Retrieving Data - Cleansing, Integrating, and Transforming Data - Exploratory Data Analysis - Build the Model.

Unit II **[16 hours]**

Overview Of Python and Data Structures: Basics of Python Including Data Types, Variables, Expressions, Objects and Functions – Python Data Structures Including String, Array, List, Tuple, Set, Dictionary and Operations.

Unit III **[16 hours]**

Data Science and Python: Discovering the Match Between Data Science and Python: Considering the Emergence of Data Science – Outlining the Core Competencies of a Data Scientist – Creating the Data Science Pipeline – Preparing the Data – Performing Exploratory Data Analysis – Learning from Data – Understanding Python's Role in Data Science: Introducing Python's Capabilities and Wonders: Working with Python – Understanding the Need for Indentation – Working at The Command Line or In The IDE

Unit IV **[15 hours]**

Getting Your Hands Dirty with Data: Using the Jupyter Console, Interacting with Screen Text – Changing the Window Appearance – Using Magic Functions – Discovering Objects – Using Jupyter Notebook: Working with Styles – Restarting the Kernel – Restoring A Checkpoint – Performing Multimedia and Graphic Integration – Loading Examples from Online Sites – Obtaining Online Graphics and Multimedia**.**

Unit V **[16 hours]**

Visualizing Information: Starting With a Graph – Defining the Plot – Drawing Multiple Lines and Plots – Setting the Axis – Adding Grids – Defining the Line Appearance – Working with Line Style –Using Colors – Adding Markers – Using Labels – Annotations and Legends – Choosing the Right Graph –Creating Comparisons with Bar Charts, Histograms, Boxplots, Scatterplots, Plotting Time Series.

Suggested Readings:

Davy Cielen, Arno D. B. Meysman and Mohamed Ali, "*Introducing Data Science"*, Dreamtech Publications, 2016

John Paul Mueller, Luca Massaron, "*Python for Data Science for Dummies*", Wiley publications, 2nd Edition, 2019.

References:

Daniel Y. Chen, "*Pandas for Everyone: Python Data Analysis"*, Pearson, 2nd Edition, 2023.

Brian Godsey, "*Think Like a Data Scientist*", Manning Publications, 1st Edition, 2017.

Course Code : **BCS503** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **DESIGN AND ANALYSIS OF ALGORITHMS**

Course Objectives:

- To comprehend algorithm design fundamentals like pseudo code, space/time complexity analysis, and asymptotic notation.
- To acquire knowledge of divide and conquer algorithms such as binary search, quick sort, and merge sort, including their practical applications.
- To explore searching and traversal techniques encompassing binary tree traversals and graph traversals.
- To develop proficiency in greedy method, dynamic programming, and backtracking algorithms, and apply them to solve diverse computational problems.

Learning Outcomes:

After completion of the course, students will be able to

- Analyze algorithms and improve the efficiency of algorithms.
- Understand and estimate the performance of algorithm.
- Apply different designing methods for development of algorithms to realistic problems, such as divide and conquer, dynamic programming, greedy etc.

Course Outline:

Unit I **[12 hours]**

Introduction: Algorithm – Pseudo Code for Expressing Algorithms – Space Complexity and Time Complexity – Asymptotic Notation- Big Oh Notation, Omega Notation, Theta Notation and Little Oh Notation – Amortized Analysis. Divide And Conquer: General Method – Applications – Binary Search – Quick Sort – Merge Sort.

Unit II **[12 hours]**

Searching And Traversal Techniques: Binary Tree Traversal Algorithm – Disjoint Set Operations – Union and Find Algorithms – Spanning Trees – Graph Traversals: Breadth First Search and Depth First Search, AND / OR Graphs- Game Trees – Connected Components – Bi - Connected Components. Disjoint Sets: Union and Find Algorithms- Spanning Trees –Connected Components and Biconnected Components.

Unit III **[12 hours]**

Greedy Method: General Method, Applications - Job Sequencing with Deadlines – 0/1 Knapsack Problem, Minimum Cost Spanning Trees – Single Source Shortest Path Problem.

Unit IV **[12 hours]**

Dynamic Programming: General method – Applications – Matrix Chain Multiplication – Optimal Binary Search Trees – 0/1 Knapsack Problem – All Pairs Shortest Path Problem – Travelling Sales Person Problem.

Unit V **[12 hours]**

Backtracking: General Method – Applications, N-Queen's Problem – Sum of Subsets Problem – Graph Coloring – Hamiltonian Cycles.

Suggested Readings:

Ellis Horowitz, Satraj Sahni and Rajasekharam, "*Fundamentals of Computer Algorithms*", Galgotia publications pvt. Ltd, 2nd Edition, 2018.

References:

R. Neapolitan and K. Naimipour, "*Foundations of Algorithm,*" Jones and Bartlett Learning, 4th edition,2010.

P. H. Dave, H. B. Dave, "*Design and Analysis of Algorithms*", Pearson Education, 2008.

M. T. Goodrich and R. Tomassia, "*Algorithm Design: Foundations, Analysis and Internet examples,*" Wiley, 1st Edition, 2006.

Course Code : **BCS504** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **BASICS OF CLOUD COMPUTING**

Course Objectives:

- To understand the cloud computing reference model, its characteristics, benefits, and historical developments.
- To explore cloud computing architecture, economics, and various types of clouds.
- To learn about virtualization techniques.
- To gain insights into cloud data management along with parallel computing models.

Learning Outcomes:

After completion of the course, students will be able to

- Understand various service delivery models of a cloud computing
- Understand the virtualization and cloud computing concepts
- Explore some important cloud computing driven commercial systems and applications
- Evaluate virtualization technologies, including VMware and its full virtualization, and understand their integration with cloud computing.

Course Outline:

Unit-I **[12 hours]**

The Vision of Cloud Computing: The Cloud Computing Reference Model - Characteristics and Benefits - Historical Developments - Building Cloud Computing Environments - Application Development - Infrastructure and System Development - Computing Platforms.

Unit-II **[12 hours]**

Cloud Computing Architecture and Economics: The Cloud Reference Model - Types of Clouds - Economics of the Cloud - Cloud Infrastructure - Private Clouds - Software Productivity in the Cloud - Open Challenges.

Unit-III **[12 hours]**

Virtualization: Characteristics of Virtualized Environments - Taxonomy of Virtualization Techniques - Virtualization and Cloud Computing - Pros and Cons of Virtualization - Technology Example: VMWARE: Full Virtualization.

Unit-IV **[12 hours]**

Data in the Cloud: Relational Databases - Cloud File Systems: GFS And HDFS - Big Table - Hbase - Dynamo - Cloud Data Stores: Datastore and Simple DB- MAPREDUCE and Extensions - Parallel Computing-MAPREDUCE Model - Relational Operations Using MAPREDUCE.

Unit-V **[12 hours]**

Cloud Platforms in Industry: Healthcare: ECG Analysis in the Cloud - Biology: Protein Structure Prediction - Biology: Gene Expression Data Analysis for Cancer Diagnosis - Geoscience: Satellite Image Processing.

Suggested Readings:

Gautam Shroff, "*Enterprise Cloud Computing: Technology, Architecture, Applications*", Cambridge University Press, 2010

Rajkumar Buyya, Christian Vecchiola and S. Thamarai Selvi, "*Mastering Cloud Computing" - Foundations and Applications Programming"*, MK publications, 2013.

References:

Antonopoulos, N., & Gillam, L. "*Cloud computing*". London: Springer, 2013.

Thomas Erl, "Cloud Computing: Concepts, Technology, and Architecture", Pearson Education, 2nd Edition, 2024.

Course Code : **BCS511** Course Type : **Minor** No. of Credits : **4** No. of Hours : **60**	Course Title **Ethics and Social Implications of Artificial Intelligence**

Course Objectives:

- To introduce students to the ethical considerations surrounding the development and deployment of artificial intelligence (AI) technologies.
- To provide an understanding of the role of ethics in AI and its implications for human life.
- To explore various frameworks, models, and perspectives used to govern AI systems and ensure their alignment with human rights and ethical principles.
- To analyze real-world cases and applications of AI ethics across different domains including transportation, military, healthcare, education, policy, and smart cities.

Learning Outcomes:

After completion of the course, students will be able to

- Define and explain the significance of ethics in the context of artificial intelligence.
- Identify and evaluate ethical considerations inherent in the development and deployment of AI technologies.
- Analyze the ethical implications of AI on accountability, transparency, and responsibility within computer systems.

Course Outline:

Unit-I **[12 hours]**

Introduction To Ethics of AI Role of Artificial Intelligence in Human Life, Understanding Ethics, Why Ethics in AI? Ethical Considerations of AI, Current Initiatives in AI and Ethics, Ethical Issues with our Relationship with Artificial Entities

Unit-II **[12 hours]**

Framework And Models AI Governance by Human-Right Centred Design, Normative Models, Role of Professional Norms, Teaching Machines to be Moral

Unit-III **[12 hours]**

Concepts And Issues Accountability in Computer Systems, Transparency, Responsibility and AI. Race and Gender, AI as a Moral Right-holder

Unit-IV **[12 hours]**

Perspectives And Approaches Perspectives on Ethics of AI, Integrating Ethical Values and Economic Value, Automating Origination, AI a Binary Approach, Machine Learning Values, Artificial Moral Agent

Unit-V **[12 hours]**

Cases And Application Ethics of Artificial Intelligence in Transport, Ethical AI in Military, Biomedical research, Patient Care, Public Health, Robot Teaching, Pedagogy, Policy, Smart City Ethics.

Suggested Readings:

Paula Boddington, "*Towards a Code of Ethics for Artificial Intelligence"*, Springer, 2017

Markus D. Dubber, Frank Pasquale, Sunit Das, "*The Oxford Handbook of Ethics of AI*", Oxford University Press Edited book, 2020

References:

S. Matthew Liao, "*Ethics of Artificial Intelligence*", Oxford University Press Edited Book, 2020

Wallach, W., & Allen, C, "*Moral machines: Teaching robots right from wrong*", Oxford University Press, 2008.

SEMESTER-VI

Course Code : **BCS601** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **DATA MINING & DATA WAREHOUSING**

Course Objectives:

- To understand the concepts of Data Mining and Data Warehousing.
- To gain knowledge about Data pre-processing, applying mining techniques.
- To explore cluster analysis, including its requirements, methods, evaluation, and outlier analysis.
- To understand emerging trends in data mining methodologies and applications.

Learning Outcomes:

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

- Understand data mining fundamentals, encompassing various technologies, applications, and significant challenges.
- Attain expertise in data pre-processing tasks, including cleaning, integration, reduction, transformation, and discretization.
- Develop proficiency in mining frequent patterns, associations, and classifications etc.
- Explore cluster analysis, outlier detection, and current trends in data mining methodologies and applications.

Course Outline:

Unit-I **[12 hours]**

Introduction to Data Mining: Different Kinds of Data and Patterns - Technologies Used - Applications - Major Issues in Data Mining - Data Objects and Attribute Types - Basic Statistical Description of Data - Data Visualization - Measuring Data Similarity and Dissimilarity.

Unit-II **[16 hours]**

Data Pre-Processing: Overview Of Data Pre-Processing - Major Tasks in Data Pre-Processing - Data Cleaning - Data Integration - Data Value Conflict Detection and Resolution - Data Reduction - Data Transformation - Data Discretization, Concept Hierarchy for Nominal Data.

Unit-III **[16 hours]**

Mining Frequent Patterns, Associations and Correlations: Frequent Itemset Mining Methods - Pattern Evaluation Methods - Applications of Pattern Mining - Classification - Decision Tree Induction - Bayes Classification Methods - Rule-Based Classification.

Unit-IV **[16 hours]**

Cluster Analysis: Cluster Analysis Requirements - Clustering Methods - Evaluation of Clustering - Outlier Analysis - Data Mining Trends: Other Methodologies of Data Mining - Data Mining Applications and Data Mining Trends.

Unit-V **[15 hours]**

Data Warehousing and Online Analytical Processing: Operational Database Systems Vs. Data Warehouses - Data Warehouse Architecture - Data Warehouse Modelling - Data Cube and OLAP - Data Warehouse Design and Usage - Data Warehouse Implementation.

Suggested Readings:

J Han, M Kamber, J Pei, "*Data Mining Concepts and Techniques",* Morgan Kaufman Publishers, 3rd edition, 2011.

Charu C. Aggarwal, "*Data Mining: The Textbook*", Springer, 2015.

References:

Paulraj Ponnaiah, "*Data Warehousing Fundamentals*", Wiley Publishers, Reprint 2011

Roiger, Michael W. Geatz, "*Data Mining, A Tutorial-Based Primer*", Pearson Education, 1st Edition, 2005.

Course Code : **BCS602** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **COMPUTER NETWORKS**

Course Objectives:

- To introduce the fundamental principles, concepts, and protocols of computer networks.
- To provide students with practical skills in designing, implementing, and troubleshooting computer networks.
- To understand the role of computer networks in modern communication systems and their impact on various industries and society.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basic concepts and components of computer networks, including network architectures, protocols, and addressing schemes.
- Design and implement small to medium-sized computer networks using appropriate networking devices and technologies.
- Analyze and troubleshoot common network problems and perform network optimization to ensure efficient and reliable communication.

Course Outline:

Unit-I **[15 hours]**

Introduction: Network Applications, Network Hardware, Network Software, Reference Models: OSI, TCP/IP, Internet, Connection Oriented Network - X.25, Frame Relay. The Physical Layer: Theoretical Basis for Communication, Guided Transmission Media, Wireless Transmission, The Public Switched Telephone Networks, Mobile Telephone System.

Unit-II **[15 hours]**

The Data Link Layer: Design Issues, Error Detection and Correction, Elementary Data Link Protocols, Sliding Window Protocols, Example Data Link Protocols - HDLC, The Data Link Layer in The Internet. The Medium Access Sublayer: Channel Allocations Problem, Multiple Access Protocols, Ethernet, Data Link Layer Switching, Wireless LAN, Broadband Wireless, Bluetooth

Unit-III **[15 hours]**

The Network Layer: Network Layer Design Issues, Routing Algorithms, Congestion Control Algorithms, Internetworking, The Network Layer in The Internet (Ipv4 and Ipv6), Quality of Service.

Unit-IV **[15 hours]**

The Transport Layer: Transport Service, Elements of Transport Protocol, Simple Transport Protocol, Internet Transport Layer Protocols: UDP And TCP.

Unit-V **[15 hours]**

The Application Layer: Domain Name System, Electronic Mail, World Wide Web: Architectural Overview, Dynamic Web Document and Http. Application Layer Protocols: Simple Network Management Protocol, File Transfer Protocol, Simple Mail Transfer Protocol, Telnet.

Suggested Readings:

Andrew S Tanenbaum, "*Computer Networks*", Pearson, 6th Edition, 2020.

References:

Behrouz A. Forouzan, "*Data Communications and Networking,"* TMH, 5th Edition, 2013.

James F. Kurose, K. W. Ross, "*Computer Networking: A Top-Down Approach Featuring the Internet*," Pearson Education, 6th Edition, 2017.

Course Code : **BCS603** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO INFORMATION SECURITY**

Course Objectives:

- To provide an understanding of principal concepts, technologies, and basic approaches in information security.
- To introduce the key concepts of information security and how they "work.
- To provide the ability to examine and analyze real-life security cases.

Learning Outcomes:

After completion of the course, students will be able to

- Demonstrate basic principles of Web application security.
- Demonstrate how to secure a network.
- Evaluate vulnerability of an information system and establish a plan for risk management.

Course Outline:

Unit I **[12 hours]**

Introduction: Security Mindset Computer Security Concepts (CIA), Threats, Attacks, And Assets (05) Software Security: Vulnerabilities and Protections, Malware, Program Analysis

Unit II **[12 hours]**

Practical Cryptography: Encryption, Authentication, Hashing, Symmetric and Asymmetric Cryptography, Digital Signatures and Certificates

Unit III **[12 hours]**

Network Security: Network Security Issues, Sniffing, IP Spoofing, Common Threats, E-Mail Security, IPsec, SSL, PGP, Intruders, Virus, Worms, Firewalls-Need and Features of Firewall, Types of Firewalls, Intruder Detection Systems.

Unit IV **[12 hours]**

Cyber Security: Cyber Crime and Security, Security Tools, Introduction to Digital Forensic, OS Fingerprinting, TCP/IP Stack Masking, Social Engineering.

Unit V **[12 hours]**

Applications And Special Topics: Web Application Security, Privacy and Anonymity, Public Policy.

Suggested Readings:

William Stallings, Lawrie Brown, "*Computer Security: Principles and Practice*", Pearson, 4th Edition, 2018
Stallings William, "*Cryptography and Network Security*", Pearson, 8th Edition,2023.

References:

Matt Bishop, "*Introduction to Computer Security*", Pearson, 1st Edition 2005
Buchmann J. A, "*Introduction to Cryptography"*, Springer, 2nd Edition, 2009.
Bruce Schneier*, "Applied Cryptography"*, John Wiley and Sons, 2015.
Britz M., "*Computer Forensic and Cyber Crime"*, Pearson, 2nd Edition, 2011.

Course Code : **BCS604** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **ADVANCED DATABASE MANAGEMENT SYSTEMS**

Course Objectives:

- To comprehend relational databases, functional dependencies, implication, closure, and correctness.
- To achieve expertise in normalization principles.
- To understand processing joins and transaction management.
- To develop proficiency in concurrency control mechanisms and distributed transaction concepts

Learning Outcomes*:*

After completion of the course, students will be able to

- Analyze and apply normalization techniques
- Develop skills in processing joins, grasp materialized vs. pipelined processing
- Learn principles of correct interleaved execution, locking mechanisms (2PL), handle deadlocks.

Course Outline:

Unit-I **[12 hours]**

Formal Review of Relational Database and FD's Implication, Closure, Its Correctness

Unit-II **[12 hours]**

3NF And BCNF, Higher Normal Forms - Introduction, Multi-Valued Dependencies and Fourth Normal Form, Join Dependencies and Fifth Normal Form.

Unit-III **[12 hours]**

Processing Of Joins, Materialized Vs. Pipelined Processing, Query Transformation Rules, DB Transactions, ACID Properties, Interleaved Executions, Schedules, Serializability

Unit-IV **[12 hours]**

Correctness Of Interleaved Execution, Locking and Management of Locks, 2PL, Deadlocks, Multiple Level Granularity, CC On B+ Trees, Optimistic Concurrency Control and The Concepts Related to Global and Local Transactions in Distributed Transactions.

Unit V **[12 hours]**

T/O Based Techniques, Multi-Version Approaches, Comparison of Concurrency Control Methods, Dynamic Databases, Failure Classification, Recovery Algorithm, XML And Relational Databases.

Suggested Readings:

R. Ramakrishnan, J. Gehrke, "*Database Management Systems*," McGraw Hill, 3rd Edition 2022

References:

Silberschatz, H. Korth, S. Sudarshan, "*Database System Concepts,"* McGraw Hill, 7th Edition 2021.

Hector Garcia-Molina, Jeff Ullman, and Jennifer Widom, "*Database Systems: The Complete Book,"* Pearson, 2nd Edition, 2013.

Course Code : **BCS604** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **DISTRIBUTED SYSTEMS**

Course Objectives:

- To learn the principles, architectures, algorithms, and programming models used in distributed systems.
- To examine state-of-the-art distributed systems, such as Google File System.
- To design and implement sample distributed systems.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basic principles of Distributed systems including scalability, fault tolerance, consistency, and concurrency control.
- Evaluate, select, and implement appropriate architectural patterns and technologies for building distributed systems, such as client-server, peer-to-peer, microservices, or event-driven architectures.

Course Outline:

Unit I **[10 hours]**

Characterization Of Distributed Systems: Introduction, Examples of Distributed Systems, Resource Sharing and Web, Challenges. System Models: Introduction, Architectural and Fundamental Models.

Unit II **[14 hours]**

Time and Global States: Introduction, Clocks, Events and Process States, Synchronizing Physical Clocks, Logical Time and Logical Clocks, Global States, Distributed Debugging. Coordination And Agreement: Introduction, Distributed Mutual Exclusion, Elections, Multicast Communication, Consensus and Related Problems.

Unit III **[12 hours]**

Inter Process Communication: Introduction, The API For the Internet Protocols, External Data Representation and Marshalling, Client-Server Communication, Group Communication, Case Study: IPC in UNIX. Distributed Objects and Remote Invocation: Introduction, Communication Between Distributed Objects, Remote Procedure Call, Events and Notifications, Case Study-Java RMI.

Unit IV **[14 hours]**

Distributed File Systems: Introduction, File Service Architecture, Case Study1: Sun Network File System, Case Study 2: The Andrew File System. Name Services: Introduction, Name Services and The Domain Name System, Directory Services, Case Study of The Global Name Service. Distributed Shared Memory: Introduction Design and Implementation Issues, Sequential Consistency and Ivy Case Study, Release Consistency and Munin Case Study, Other Consistency Models.

Unit V **[10 hours]**

Transactions And Concurrency Control: Introduction, Transactions, Nested Transactions, Locks, Optimistic Concurrency Control, Timestamp Ordering, Comparison of Methods for Concurrency Control. Distributed Transactions: Introduction, Flat and Nested Distributed Transactions, Atomic Commit Protocols, Concurrency Control in Distributed Transactions, Distributed Deadlocks, Transaction Recovery

Suggested Readings:

George Coulouris, J Dollimore and Tim Kindberg, "*Distributed Systems, Concepts and Design*", Pearson Education, 5th Edition, 2017.

References:

Andrew Tanenbaum, Maarten Van Steen, "*Distributed Systems, Principles and Paradigms*," Pearson Education, 2nd Edition, 2015.

Sukumar Ghosh, "*Distributed Systems: An Algorithm Approach*", CRC Press, 2nd Edition, 2020.

Course Code : **BCS604** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **FUNDAMENTALS OF IoT**

Course Objectives:

- To understand the fundamentals of Internet of Things
- To understand the application areas of IoT
- To Investigate IoT and architecture, emphasizing design principles, capabilities, and standards considerations; To examine IoT development challenges and domain-specific applications.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the fundamentals of IoT.
- Explore the relationship between IoT and Machine-to-Machine (M2M) communication, analyzing IoT value chains, emerging industrial structures, and architectural principles.
- Apply the concept of Internet of Things in the real-world scenario

Course Outline:

Unit I **[12 hours]**

Introduction To IoT: Defining IoT - Characteristics of IoT - Physical Design of IoT - Logical Design of IoT - Functional Blocks of IoT - IoT Protocols - IoT Levels & Deployment Templates - Communication Models & Apis.

Unit II **[12 hours]**

IoT & M2M - M2M Value Chains: IoT Value Chains - An Emerging Industrial Structure for IoT - The International Driven - Global Value Chain and Global Information Monopolies - Building Architecture - Main Design - Principles and Needed Capabilities - An IoT Architecture Outline - Standards Considerations.

Unit III **[12 hours]**

Challenges In IoT: Design Challenges - Development Challenges - Security Challenges - Challenges in Terms of Scalability - Security and Privacy - Energy Efficiency - Healthcare - Supply Chain - Education, Training and Other Challenges.

Unit IV **[14 hours]**

Domain Specific Applications of IoT: Home Automation - Industry Applications - Surveillance Applications - Other IoT Applications - Smart Objects - Smart Applications - Four Aspects in Your Business to Master IoT - Value - Creation from Big Data and Serialization - IoT for Retailing Industry - IoT for Oil and Gas - Industry - Opinions on IoT Application and Value for Industry - Home Management - E-Health.

Unit V **[10 hours]**

Developing IoTs: Implementing IoT Concepts with Python - Implementing Different IoT Tools - Developing Applications Through IoT Tools.

Suggested Readings:

Vijay Madisetti, Arshdeep Bahga, "*Internet of Things: A Hands-On Approach*", Orient Black Swan Private Limited, 1st Edition, 2015.

Shriram K Vasudevan, "*Internet of Things*", Wiley, 2nd Edition, 2020.

References:

Samuel Greengard, "*The Internet of Things*", MIT Press, 2nd Edition, 2021.

Raj Kamal, "*Internet of Things: Architecture and Design Principles*", Tata Mc Graw Hill, 2nd Edition, 2022.

Course Code : **BCS611** Course Type : **Minor** No. of Credits : **4** No. of Hours : **60**	Course Title **DATA ANALYSIS AND VISUALIZATION**

Course Objectives:

- To understand data gathering, preparation, and scalability.
- To develop proficiency in data cleaning and transformation.
- To gain skills in exploratory analysis and hypothesis generation.
- To learn data visualization using Python tools for enhanced interpretation.

Learning Outcomes:

After completion of the course, students will be able to

- Understand data gathering and preparation techniques through analysis and evaluation.
- Apply data cleaning methods effectively using synthesis and creation.
- Demonstrate comprehension of exploratory analysis techniques by evaluating and analyzing data.
- Develop proficient data visualization skills using Python libraries.

Course Outline:

Unit-I **[12 hours]**

Data Gathering and Preparation: Data Formats, Parsing and Transformation, Scalability, and Real-Time Issues.

Unit-II **[12 hours]**

Data Cleaning: Consistency Checking, Heterogeneous and Missing Data, Data Transformation and Segmentation.

Unit-III **[12 hours]**

Exploratory Analysis: Descriptive and Comparative Statistics, Clustering and Association, Hypothesis Generation.

Unit-IV **[12 hours]**

Data Visualization Tools in Python- Introduction to Matplotlib, Basic Plots Using Matplotlib, Specialized Visualization Tools Using Matplotlib.

Unit V **[12 hours]**

Introduction To Seaborn: Seaborn Functionalities and Usage, Spatial Visualizations And Analysis

Suggested Readings:

Glenn J. Myatt, "*Making Sense of Data: A Practical Guide to Exploratory Data Analysis and Data Mining,*" John Wiley Publishers, 2nd Edition, 2014.
William McKinney, "*Python for Data Analysis*", O'Reilly Media Inc., 2nd Edition, 2017.

References:

Dr. Ossama Embarak, "*Data Analysis and Visualization Using Python,*" Apress, 1st Edition, 2018.
Stefanie Molin, " *Hands- on Data Analysis with Pandas,*" Packt Publishing, 2nd Edition,2021.

SEMESTER-VII

Course Code : **BCS701** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **ADVANCED JAVA PROGRAMMING**

Course Objectives*:*

- To learn Applet Programming basics and understand its life cycle.
- To explore J2EE platform components and architecture.
- To understand JDBC and Servlet programming for database connections and web applications.
- Gain proficiency in Java Server Pages (JSP) for dynamic web content creation.

Learning Outcomes:

After completion of the course, students will be able to

- Describe the components of J2EE Architecture
- To make use of Servlet and JSP API in the process of application deployment.
- Apply knowledge of J2EE platform components with synthesis and creation in enterprise architecture.
- Demonstrate proficiency in JDBC database programming by evaluating and analyzing data**.**

Course Outline:

Unit I **[15 hours]**

Applet Programming: Local And Remote Applets, Applets and Applications, Building Applet Code, Applet Life Cycle: Initialization State, Running State, Idle or Stopped State, Dead State, Display State.

Unit II **[16 hours]**

J2EE Platform – Enterprise Architecture Styles – J2EE Run Times – J2EE API – J2EE Architecture – Containers –Introduction to J2EE Technologies – Naming and Directory Services

Unit III **[16 hours]**

Database Programming with JDBC – JDBC/ODBC Bridge – Establishing A Connection – Creating and Executing SQL Statements – Querying – Report Statements – Scrollable and Updatable Result Sets – Java. SQL Packages – JDBC Data Sources.

Unit IV **[14 hours]**

Introduction To Servlet Programming - Servlet Implementations - Servlet Configuration - Servlet Exceptions - Servlet Life Cycle - Servlet Programming - Servlet Security- Servlet Communication.

Unit V **[14 hours]**

Java Server Pages - Intro to JSP - JSP Directives - Scripting Elements - Standard Auctions - Implicit Objects - Scope - JSP Pages As XML Documents - JSP Sample Program - Design Strategies.

Suggested Readings:

Patrick Naughton & Herbert Schildt, "*The Complete Reference: Java 2*", Tata McGraw Hill, 12th 2022.
Jim Keogh, "*Completer Reference: J2EE,"* Tata McGraw Hill, 1st Edition, 2017.

References:

Deitel & Deitel, "*Java How to Program: Early Objects*", Pearson Education, 11th Edition ,2018.

Course Code : **BCS702** Course Type : **Core** No. of Credits : **4** No. of Hours : **75**	Course Title **SOFTWARE ENGINEERING**

Course Objectives:

- To comprehend the various software process models.
- To understand the types of software requirements and SRS document.
- To know the different software design and architectural styles.
- To learn the software testing approaches and metrics used in software development.

Learning Outcomes:

After completion of the course, students will be able to

- To compare and select a process model for a business system.
- To identify and specify the requirements for the development of an application.
- To develop and maintain efficient, reliable, and cost-effective software solutions.

Course Outline:

Unit I **[15 hours]**

Introduction To Software Engineering: The Evolving Role of Software, Changing Nature of Software, Software Myths. A Generic View of Process: Software Engineering- A Layered Technology, A Process Framework, The Capability Maturity Model Integration (CMMI), Process Patterns, Process Assessment, Personal and Team Process Models. Process Models: The Waterfall Model, Incremental Process Models, Evolutionary Process Models, The Unified Process.

Unit II **[16 hours]**

Software Requirements: Functional And Non-Functional Requirements, User Requirements, System Requirements, Interface Specification, The Software Requirements Document. Requirements Engineering Process: Feasibility Studies, Requirements Elicitation and Analysis, Requirements Validation, Requirements Management. System Models: Context Models, Behavioural Models, Data Models, Object Models, Structured Methods.

Unit III **[16 hours]**

Design Engineering: Design Process and Design Quality, Design Concepts, The Design Model. Creating An Architectural Design: Software Architecture, Data Design, Architectural Styles and Patterns, Architectural Design.

Unit IV **[16 hours]**

Testing Strategies: A Strategic Approach to Software Testing, Test Strategies for Conventional Software, Black-Box and White-Box Testing, Validation Testing, System Testing, The Art of Debugging. Product Metrics: Software Quality, Metrics for Analysis Model, Metrics for Design Model, Metrics for Source Code, Metrics for Testing, Metrics for Maintenance. Metrics For Process and Products: Software Measurement, Metrics for Software Quality.

Unit V **[12 hours]**

Risk Management: Reactive Vs Proactive Risk Strategies, Software Risks, Risk Identification, Risk Projection, Risk Refinement, RMMM, RMMM Plan. Quality Management: Quality Concepts, Software Quality Assurance, Software Reviews, Formal Technical Reviews, Statistical Software Quality Assurance, Software Reliability, The ISO 9000 Quality Standards.

Suggested Readings:

Roger S Pressman, "*Software Engineering a Practitioner's Approach*," TMH, 9th Edition, 2023.
Ian Sommerville, "*Software Engineering",* Pearson Education, 10th Edition, 2017.

References:

Pankaj Jalote, *"Software Engineering: A Precise Approach*," Wiley India, 2010.
Waman S Jawadekar, "*Software Engineering: A Primer,"* TMH, 2008
Deepak Jain, "*Software Engineering, Principles and Practices*", Oxford University Press, 2008.

Course Code : **BCS703** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **MOBILE APPLICATION DEVELOPMENT**

Course Objectives:

- To understand the fundamental concepts of mobile app development, characteristics, and user-interface design.
- To familiarize oneself with basics of graphics, multimedia, and their relevance in mobile applications.
- To gain knowledge about testing and publishing of Android application

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basics of mobile application development.
- Develop Android application with User interface, networking and animation.
- Analyze Android application components and development framework.
- Create user interfaces using Android Manifest file and resource externalization.

Course Outline:

Unit - I **[12 hours]**

Introduction To Android Operating System: Android OS and Features – Android Development Framework; Installing and Running Applications on Android Studio, Creating AVDs, Types of Android Application; Creating Activities, Activity Life Cycle, Activity States, Monitoring State Changes.

Unit - II **[12 hours]**

Android Application Components – Android Manifest File, Externalizing Recourses Like Simple Values, Drawables, Layouts, Menus, Etc., Building User Interfaces: Fundamental Android UI Design, Layouts – Linear, Relative, Grid and Table Layouts. User Interface (UI) Components

Unit - III **[12 hours]**

Fragments – Creating Fragments, Lifecycle of Fragments, Fragment States, Adding Fragments to Activity, Adding, Removing and Replacing Fragments with Fragment Transactions, Interfacing Between Fragments and Activities

Unit - IV **[12 hours]**

Intents And Broadcasts: Using Intents to Launch Activities, Types of Intents, Passing Data to Intents, Getting Results from Activities, Broadcast Receivers – Using Intent Filters to Service Implicit Intents, Resolving Intent Filters;

Unit - V **[12 hours]**

Database: Introduction To SQLITE Database, Creating and Opening a Database, Creating Tables, Inserting Retrieving and Deleting Data;

Suggested Readings:

Reto Meier, "*Professional Android 4 Application Development*", Wiley India, 2012.

James C Sheusi, "*Android Application Development for Java Programmers*", Cengage Learning, 1st Edition, 2013

References:

Wei-Meng Lee, "*Beginning Android 4 Application Development*", Wiley India (Wrox), 2013

Pradeep Kothari, *"Android Application Development (with Kitkat Support), Black Book,"* Dreamtech Press Publisher, 2014

Erik Hellman, "*Android Programming: Pushing the Limits*", 1st Edition, Wiley Publications, 2014.

Course Code : **BCS703** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO BLOCKCHAIN TECHNOLOGY**

Course Objectives:

- To understand fundamentals of blockchain technology and application of cryptography in blockchain
- To gain the awareness about the concepts of various implementations of blockchain technology such as bitcoin and Hyper ledger.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the fundamentals of blockchain technology.
- Explore the decentralized nature and security features of blockchain.
- Apply knowledge of implementations of Bitcoin, Ethereum and Hyperledger to develop solutions in the appropriate domains.
- Analyze the potential impact and future trends of blockchain technology.

Course Outline:

Unit I **[12 hours]**

Basics of Blockchain-Public Ledgers-Block Chain as Public Ledgers-Types of Block Chains- Pillars of Block Chain- Government Initiatives of Block Chain – Bitcoin – Smart Contracts.

Unit II **[12 hours]**

Architecture And Conceptualization of Block Chain, Crypto Currencies- Block in A Block Chain-Find Transactions-Distributed Consensus-Proof of Work, Stake, Space-Attacks on Pow-Ethereum-Pos/Pow Hybrids-Crypto Currency to Block Chain 2.0, Model of Blockchain- ALGORAND.

Unit III **[12 hours]**

Crypto Primitives, Securing and Interconnecting Public and Private Block Chains- Hash Function and Merle Tree-Security Properties-Security Considerations for Block Chain, Digital Signature-Public Key Cryptography-Bitcoin Blockchain Incentive Structures- Nash Equilibriums- Evolutionary Stable Strategies -And Pareto Efficiency (Game Theory) Weaknesses and News Points of Failure, Mitigation Methods, Redundancies and Fall-Back Methods.

Unit IV **[12 hours]**

Mining And Crypto Currencies - How to Use and Interact Mining-Pools-Impact of CPU and GPU-Transaction in Bit Coin Network- Block Mining Block Propagation and Block Relay.

Unit V **[12 hours]**

Use Cases-Applications in Different Areas-Industry Applications of Blockchain - Blockchain in Government-Government Use Cases-Preventing Cybercrime Through Block Chain-Block Chain in Défense, Tax Payments.

Suggested Readings:

Andreas Antonopoulos, "*Mastering Bitcoin: Unlocking Digital Cryptocurrencies*," O'Reilly, 1st Edition, 2014.

References:

Melanie Swa, "*Blockchain*", O'Reilly Media, 2015.

Bob Dill, David Smits, "*Zero to Block chain - An IBM Redbooks course*".

Course Code : **BCS703** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **FUNDAMENTALS OF DIGITAL FORENSICS**

Course Objectives:

- To understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices.
- To understand how to examine digital evidences such as the data acquisition, identification analysis

Learning Outcomes:

After completion of the course, students will be able to

- Understand the Basics of digital forensics
- Understand the concepts of investigations and procedures
- Apply the different digital forensic tools
- Understand and apply tools and techniques in digital forensic

Course Outline:

Unit I **[12 hours]**

Computer Forensics Fundamentals, Benefits of Forensics, Computer Crimes, Computer Forensics Evidence and Courts, Legal Concerns, And Private Issues.

Unit II **[12 hours]**

Data Acquisition- Understanding Storage Formats and Digital Evidence, Determining the Best Acquisition Method, Acquisition Tools, Validating Data Acquisitions, Performing RAID Data Acquisitions, Remote Network Acquisition Tools, Other Forensics Acquisitions Tools.

Unit III **[12 hours]**

Understanding Computing Investigations – Procedure for Corporate High-Tech Investigations, Understanding Data Recovery Work Station, and Software, Conducting and Investigations.

Unit IV **[12 hours]**

Processing Crimes and Incident Scenes, Securing A Computer Incident or Crime, Seizing Digital Evidence at Scene, Storing Digital Evidence, Obtaining Digital Hash, Reviewing Case.

Unit V **[12 hours]**

Current Computer Forensics Tools- Software, Hardware Tools, Validating and Testing Forensic Software, Addressing Data-Hiding Techniques, Performing Remote Acquisitions, E-Mail Investigations- Investigating Email Crime and Violations, Understanding E-Mail Servers, Specialized E-Mail Forensics Tool.

Suggested Readings:

Warren G. Kruse II and Jay G. Heiser, "*Computer Forensics: Incident Response Essentials*", Addison Wesley, 2002.

References:

Nelson. B, Phillips. A, Stuart. C., "*Guide to Computer Forensics and Investigations*," Cengage, 6th Edition, 2020.
Vacca, J, "*Computer Forensics: Computer Crime Scene Investigation*", Charles River Media, 2005.

Course Code : **BCS711** Course Type : **Minor Elective I** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO REINFORCEMENT LEARNING**

Course Objectives:

- To the basics concepts of reinforcement learning.
- To understand how reinforcement learning along with supervised and unsupervised learning form a building block of modern artificial intelligence.
- To explore finite Markov decision processes, including policies, value functions, and dynamic programming.

Learning Outcomes:

After completion of the course, students will be able to

- Understand reinforcement learning concepts and where they fit in the machine learning landscape.
- Develop the ability to take a machine learning problem and figure out when it is appropriate to model the problem as a reinforcement learning problem, and how to do that.
- Acquire knowledge of approximate solution methods and value-function approximation for on-policy control.

Course Outline:

Unit I **[10 hours]**

Introduction To Reinforcement Learning: Examples of Reinforcement Learning, Elements of Reinforcement Learning - Tabular and Approximate Solution Methods: Multi-Armed Bandits, Action-Value Methods, Incremental Implementation, Upper-Confidence-Bound Action Selection, Gradient Bandit Algorithms - Associative Search

Unit II **[12 hours]**

Finite Markov Decision Processes -- The Agent-Environment Interface -- Goals and Rewards -- Returns and Episodes -- Policies and Value Functions -- Optimality of Policies and Value Functions -- Optimality and Approximation – Dynamic Programming -- Policy Evaluation -- Policy Improvement - Policy Iteration - Value Iteration -- Asynchronous Dynamic Programming -- Generalized Policy Iteration.

Unit III **[14 hours]**

Monte Carlo Methods -- Monte Carlo Prediction -- Estimation of Action Values -- Monte Carlo Control -- Control Without Exploring Starts -- Off-Policy Prediction Via Importance Sampling -- Incremental Implementation -- Off-Policy Monte Carlo Control – Temporal Difference Learning -- TD Prediction -- Advantages of TD Methods -- Optimality of TD (0) -- Sarsa And Q-Learning -- Expected Sarsa -- Maximization Bias, Double Learning -- Special Cases.

Unit IV **[12 hours]**

N-Step Bootstrapping -- N-Step TD Prediction -- N-Step Sarsa -- N-Step Off-Policy Learning -- Off-Policy Learning Without Importance Sampling -- Planning and Learning with Tabular Methods -- Models and Planning -- Dyna -- Prioritized Sweeping -- Expected Vs. Sample Updates -- Trajectory Sampling -- Real-Time Dynamic Programming -- Heuristic Search -- Rollout Algorithms -- Monte Carlo Tree Search.

Unit V **[12 hours]**

Approximate Solution Methods -- on-Policy Prediction With Approximation -- Value-Function Approximation -- Prediction Objective -- Stochastic-Gradient And Semi-Gradient Methods -- Linear Methods -- Feature Construction For Linear Methods -- Manual Selection of Step-Size Parameters -- Nonlinear Function

Approximation Using ANN -- Least-Squares TD – Memory Based Function Approximation -- Kernel-Based Function Approximation – On Policy Control With Approximation -- Episodic Semi-Gradient Control -- Semi-Gradient N-Step Sarsa -- Average Reward -- Deprecating The Discounted Setting -- Differential Semi-Gradient N-Step Sarsa .

Suggested Readings:

Richard S. Sutton and Andrew G. Barto, "*Reinforcement Learning: An Introduction*," MIT Press, 2018.

References:

Marco Wiering and Martijn van Otterlo, "*Reinforcement Learning: State-of-the Art*," Springer, 2012

Csaba Szepesvari, "*Algorithms for Reinforcement Learning*", Morgan and Claypool Publishers, 2010

Course Code : **BCS711** Course Type : **Minor Elective I** No. of Credits : **4** No. of Hours : **60**	Course Title **SPEECH RECOGNITION SYSTEMS**

Course Objectives:

- To understand acoustic theory behind the human speech production and speech perception systems.
- To analyze and estimate the acoustic features from a speech signal.
- To understand the AI based algorithms used for speech modeling enable the students to develop various speech systems.
- To understand text to speech conversion and its application

Learning Outcomes:

After completion of the course, students will be able to

- Infer knowledge about acoustics of speech production and perception.
- Analyzing efficient speech features used for modelling.
- Evaluate different Speech modelling mechanism
- Compare various speech synthesis methods

Course Outline:

Unit I **[12 hours]**

Basic Concepts: Speech Fundamentals: Articulatory Phonetics–Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of Speech Production; Review of Digital Signal Processing Concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.

Unit II **[12 hours]**

Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech Distortion Measures – Mathematical and Perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion Using A Warped Frequency Scale, LPC, PLP And MFCC Coefficients, Time Alignment And Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.

Unit III **[12 hours]**

Speech Modeling: Hidden Markov Models: Markov Processes, Hmms – Evaluation, Optimal State Sequence– Viterbi Search, Baum-Welch Parameter Re-Estimation, Implementation Issues.

Unit IV **[12 hours]**

Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of A Large Vocabulary Continuous Speech Recognition System – Acoustics and Language Models – N- Grams, Context Dependent Sub-Word Units; Applications and Present Status.

Unit V **[12 hours]**

Speech Synthesis: Text-To-Speech Synthesis: Concatenative and Waveform Synthesis Methods, Sub- Word Units For TTS, Intelligibility, And Naturalness – Role of Prosody, Applications and Present Status.

Suggested Readings:

Daniel Jurafsky and James H Martin, "*Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*", Pearson Education, 2019.

Lawrence Rabiner and Biing - Hwang Juang,"*Fundamentals of Speech Recognition*", Pearson Education,2008.

References:

Steven W. Smith, "*The Scientist and Engineer's Guide to Digital Signal Processing*", California Technical Publishing, 2011.

Himanshu Mohan, MeghaYadav, "*Speech Recognition System and its Application*", LAPLAMBERT Academic Publishing,2019.

Course Code : **BCS711** Course Type : **Minor Elective I** No. of Credits : **4** No. of Hours : **60**	Course Title **INFORMATION RETRIEVAL**

Course Objectives:

- To learn various preprocessing techniques and indexing approaches in text mining.
- To understand various clustering approaches and study different similarity measures.
- To study various search techniques in information retrieval systems.
- To know different cognitive approaches used in text retrieval systems and evaluation approaches.

Learning Outcomes*:*

After completion of the course, students will be able to

- Recognize the Boolean Model, Vector Space Model, and Probabilistic Model.
- Understand retrieval utilities and different formatting tags
- Understand cross-language information retrieval and clustering techniques

Course Outline:

Unit-I **[12 hours]**

Introduction: Definition, Objectives, Functional Overview, Relationship to DBMS, Digital Libraries and Data Warehouses. Information Retrieval System Capabilities: Search, Browse.

Unit-II **[12 hours]**

Cataloguing And Indexing: Objectives, Indexing Process, Automatic Indexing, Information Extraction. Data Structures: Introduction, Stemming Algorithms, Inverted File Structures, N-Gram Data Structure, PAT Data Structure, Signature File Structure, Hypertext Data Structure.

Unit-III **[12 hours]**

Automatic Indexing: Classes of Automatic Indexing, Statistical Indexing, Natural Language, Concept Indexing, Hypertext Linkages Document and Term Clustering: Introduction, Thesaurus Generation, Item Clustering, Hierarchy of Clusters.

Unit-IV **[12 hours]**

User Search Techniques: Search Statements and Binding, Similarity Measures and Ranking, Relevance Feedback, Selective Dissemination of Information Search, Weighted Searches of Boolean Systems, Searching The Internet And Hypertext. Information Visualization: Introduction, Cognition and Perception, Information Visualization Technologies.

Unit-V **[12 hours]**

Text Search Algorithms: Introduction, Software Text Search Algorithms, Hardware Text Search Systems. Information System Evaluation: Introduction, Measures Used in System Evaluation, Measurement Example – TREC Results.

Suggested Readings:

Gerald J. Kowalski, Mark T. Maybury, "*Information Storage and Retrieval Systems: Theory and Implementation"*, Second Edition, Springer Publishers, 2009.

Frakes, W.B., Ricardo Baeza-Yates, "I*nformation Retrieval Data Structures and Algorithms*", Prentice Hall, 1992.

References:

Yates, "Modern Information Retrieval", Pearson Education, 1st Edition, 2003.

Robert Korfhage, "Information Storage & Retrieval", John Wiley & Sons,2006.

Course Code : **BCS712** Course Type : **Minor Elective II** No. of Credits : **4** No. of Hours : **60**	Course Title **COMPUTATIONAL INTELLIGENCE**

Course Objectives:

- To understand the fundamental concepts in Computational Intelligence.
- To understand fuzzy logic and evolutionary computation.
- To apply Computational Intelligence in applications that involves perception, reasoning and learning.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the basics of computational intelligence.
- Demonstrate the applications of artificial intelligence and machine learning.
- Describe fuzzy systems, neural networks, and evolutionary computation.

Course Outline:

Unit I **[12 hours]**

Introduction: Computational Intelligence: Intelligence Machines - Computational Intelligence Paradigms – History- Expert Systems: Rule-Based Expert Systems –Uncertainty Management.

Unit II **[12 hours]**

Fuzzy Logic: Fuzzy Expert Systems: Fuzzy Sets and Operations Sets - Fuzzy Rules and Inference - Fuzzy Expert Systems.

Unit III **[12 hours]**

Artificial Neural Networks: Fundamental Neuro Computing Concepts: Artificial Neurons, Activation Functions, Neural Network Architectures, Learning Rules - Supervised Learning Neural Networks: Multi-Layer Feed Forward Neural Networks, Simple Recurrent Neural Networks, Time-Delay Neural Networks, Supervised Learning Algorithms - Unsupervised Learning Neural Networks: Self-Organizing Feature Maps - Radial Basis Function Networks -Deep Neural Networks and Learning Algorithm

Unit IV **[12 hours]**

Evolutionary Computation: Representation: Chromosomes-Fitness Functions- Selection Mechanisms -Genetic Algorithms: Crossover and Mutation - Genetic Programming.

Unit V **[12 hours]**

Applications: Natural Language Processing-Morphological Analysis-Syntax Analysis-Semantic Analysis-AII Applications Language Models - Information Retrieval – Information Extraction - Machine Translation –Machine Learning: Connectionist – Machine Learning.

Suggested Readings:

- A.P. Engelbrecht, "*Computational Intelligence: An Introduction*", John Wiley & Sons, 2nd Edition, 2012.

References:

- S. Rajasekaran and G.A. Vijayalakshmi Pai, "*Neural Networks, Fuzzy logic and Genetic Algorithms-Synthesis and Applications*", PHI Learning, 2003.
- Stuart Russell, Peter Norvig, "*Artificial Intelligence: A Modern Approach*", Pearson Education, 3rd Edition, 2010.

Course Code : **BCS712** Course Type : **Minor Elective II** No. of Credits : **4** No. of Hours : **60**	Course Title **FUNDAMENTALS OF GENERATIVE AI**

Course Objectives:

- To understand the fundamental concepts and techniques of generative modeling, deep learning, and their applications in various domains.
- To explore the cutting-edge advancements and applications of generative modeling in generating art, music, and other creative outputs, as well as its potential impact on various industries.

Learning Outcomes:

After completion of the course, students will be able to

- Differentiate between generative and discriminative modeling approaches and recognize their respective strengths and challenges.
- Develop practical skills in implementing Deep Learning models using popular frameworks such as TensorFlow and Keras, and apply them to structured and unstructured data.

Course Outline:

Unit-I **[12 hours]**

Generative Modeling: Generative Versus Discriminative Modeling - Advances in Machine Learning-The Rise of Generative Modeling - The Generative Modeling Framework -Probabilistic Generative Models - Hello Wrodl! - Your First Probabilistic Generative Model - Naive Bayes - Hello Wrodl! Continued - The Challenges of Generative Modeling - Representation Learning - Setting Up Your Environment.

Unit-II **[12 hours]**

Deep learning: Structured and Unstructured Data – Deep Neural Network- Keras and TensorFlow-Your First Deep Neural Network – Loading the Data – Building the Model – Compiling the Model – Training the Model – Evaluating the Model – Improving the model – Convolutional Layers – Batch Normalization – Dropout Layers – putting it All Together.

Unit-III **[12 hours]**

Variational Autoencoders: The Art Exhibition – Autoencoders – your First Autoencoder – The Encoder – The Decoder – Joining the Encoder to the Decoder – Analysis of the Autoencoder – The Variational Art Exhibition- Building a variational Autoencoder – The Encoder- The Loss Function – Analysis of the Variational Autoencoder – Using VAE's to Generate Faces – Training the VAE – Analysis of the VAE – Generating New Faces – Latent Space Arithmetic – Morphing Between Faces.

Unit-IV **[12 hours]**

Generative Adversarial Networks: Ganimals - Introduction to GANs - Your First GAN - The Discriminator - The Generator - Training the GAN - GAN Challenges - Oscillating Loss - Mode Collapse - Uninformative Loss - Hyperparameters - Tackling the GAN Challenges - Wasserstein GAN - Wasserstein Loss - The Lipschitz Constraint - Weight Clipping - Training the WGAN - Analysis of the WGAN - WGAN-GP - The Gradient Penalty Loss - Analysis of WGAN-GP.

Unit-V **[12 hours]**

The Future of Generative Modeling: Five Years of Progress - The Transformer - Positional Encoding - Multihead Attention - The Decoder - Analysis of the Transformer - BERT - GPT-2 -MuseNet - Advances in Image Generation - ProGAN - Self-Attention GAN (SAGAN) - BigGAN 291 StyleGAN - Applications of Generative Modeling - AI Art - AI Music.

Suggested Readings:

David Foster, "Generative Deep Learning-*Teaching Machines to Paint, Write, Compose, and Play,"* O'Reilly, 2019

Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "*Deep Learning*", MIT Press, 2016

References:

Jakub Langr and Vladimir Bok, "*GANs in Action: Deep learning with Generative Adversarial Networks*," Manning Publishers, 1st Edition, 2019.

Magnus Ekman, "*Learning Deep Learning: Theory and Practice of Neural Networks, Computer Vision, Natural Language Processing, and Transformers Using TensorFlow*", Wesley Professional, 2021

Course Code : **BCS712** Course Type : **Minor Elective II** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO ROBOTICS**

Course Objectives:

- Understand the basic principles and components of robotics systems.
- Learn about the different types of robots and their applications.
- Explore fundamental concepts in robot kinematics and dynamics.

Learning Outcomes:

After completion of the course, students will be able to

- List and explain the basic elements of industrial robots
- Classify the various sensors used in robots for better performance.
- Develop introductory skills in designing and programming robotic systems.
- Summarize various industrial and non-industrial applications of robots.

Course Outline:

Unit I **[12 hours]**

Robot-Basic Concepts, Need, Law, History, Anatomy, Specifications. Robot Configurations-Cartesian, Cylinder, Polar and Articulate. Robot Wrist Mechanism, Precision, And Accuracy of Robot.

Unit II **[12 hours]**

ROBOT ELEMENTS: End Effectors-Classification, Types of Mechanical Actuation, Gripper Design, Robot Drive System Types, Position and Velocity Feedback Devices-Robot Joints and Links-Types, Motion Interpolation.

Unit III **[14 hours]**

Robot Kinematics – Basics of Direct and Inverse Kinematics, Robot Trajectories, 2D And 3D Transformation-Scaling, Rotation, Translation Homogeneous Transformation. Control Of Robot Manipulators – Point to Point, Continuous Path Control, Robot Programming

Unit IV **[11 hours]**

ROBOT SENSORS: Sensors In Robot – Touch Sensors-Tactile Sensor – Proximity and Range Sensors. Force Sensor-Light Sensors, Pressure Sensors, Introduction to Machine Vision and Artificial Intelligence.

Unit V **[11 hours]**

ROBOT APPLICATIONS: Industrial Applications of Robots, Medical, Household, Entertainment, Space, Underwater, Défense, Disaster Management. Applications, Micro and Nanorobots, Future Applications.

Suggested Readings:

Mikell P. Groover, Mitchell Weiss, Roger N Nagel, Nicholas G Odrey, "*Industrial Robotics Technology, Programming and Applications"*, Tata –McGraw Hill Pub. Co., 2008.

Deb.S.R and Sankha Deb, "*Robotics Technology and Flexible Automation*", Tata McGraw Hill Publishing Company Limited, 2010.

References:

Klafter.R.D, Chmielewski.T.A, and Noggin's., "*Robot Engineering: An Integrated Approach*", Prentice Hall of India Pvt. Ltd., 1994.

Fu.K.S, Gonzalez.R.C&Lee.C.S.G, "*Robotics control, sensing, vision and intelligence*", Tata- McGraw Hill Pub. Co., 2008 .

Course Code : **BCS712** Course Type : **Minor Elective II** No. of Credits : **4** No. of Hours : **60**	Course Title **AI IN CLINICAL INFORMATION SYSTEMS**

Course Objectives:

- The objective of this course is to gain insight and situational experience with clinical information systems.
- To examine the effective use of data and information technology to assist in the migration away from paper-based systems and improve organizational performance.
- To gain insights and understanding of the impacts placed on patients and health care providers.

Learning Outcomes:

After completion of the course, students will be able to

- To understand the basics of clinical information systems.
- To learn how to apply information technology and related tools in workflow design.
- To explore the "benefits and barriers" associated with electronic health records.
- Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
- Explain strategies to minimize major barriers to the adoption of electronic health records.

Course Outline:

Unit I **[12 hours]**

Introduction To Clinical Information Systems – Contemporary Issues in Healthcare – Workflow and Related Tools for Workflow Design – Electronic Health Records Databases – Healthcare IT & Portable Technology

Unit II **[12 hours]**

Artificial Intelligence in Health Care: Use Of AI, The Healthcare Industry, Electronic Medical Records, Clinical Decision Support Systems

Unit III **[12 hours]**

Machine Learning for Natural Language, Machine Learning for Vision, Human-Computer Interaction

Unit IV **[12 hours]**

Bioethics And Challenges to Deployment, Grand Challenges In Clinical Decision Support

Unit V **[12 hours]**

Data Mining in Health Care, Big Data Analytics in Health Care, IBM Watson, Issues in Sustainability, and Interoperability.

Suggested Readings:

Edward H. Shortliffe; Leslie E. Perreault, Medical Informatics, "*Computer Applications in Healthcare and Biomedicine*", Springer-Verlag New York Inc. Publishers, 2014.

Sittig & Ash, "*Clinical Information Systems – Overcoming Adverse Consequences*," Jones & Bartlett Learning Publishers, 2009.

References:

Arnold, M, "*Digital Health News Update: Machine Learning Meets Health Search,"* Decision Resources Group.

SEMESTER-VIII

Course Code : **BCS801** Course Type : **Core** No. of Credits : **4** No. of Hours : **60**	Course Title **BIG DATA ANALYTICS**

Course Objectives:

- To learn the need of Big Data and the various challenges involved and to acquire Knowledge about different analytical architectures.
- To understand Hadoop Architecture and its ecosystems.
- To acquire knowledge about the NoSQL, NewSQL, MongoDB and Cassandra databases.

Learning Outcomes:

After completion of the course, students will be able to

- Demonstrate knowledge of Big Data, Data Analytics, challenges and their solutions in Big Data.
- Analyze Hadoop Framework and eco systems.
- Analyze MapReduce and Yarn, Work on NoSQL environment, NewSQL environment, MongoDB and Cassandra.

Course Outline:

Unit I **[10 hours]**

Introduction To Big Data: Data, Characteristics of Data and Types of Digital Data: Unstructured, Semi-Structured and Structured - Sources of Data. Big Data Evolution - Definition of Big Data-Characteristics and Need of Big Data-Challenges of Big Data. Big Data Analytics, Overview of Business Intelligence.

Unit II **[12 hours]**

Big Data Technologies and Databases: Hadoop – Requirement of Hadoop Framework - Design Principle of Hadoop –Comparison with Other System SQL And RDBMS- Hadoop Components – Architecture -Hadoop 1 Vs Hadoop 2.

Unit III **[13 hours]**

Mapreduce And YARN Framework: Introduction to Mapreduce, Processing Data with Hadoop Using Mapreduce, Introduction To YARN, Architecture, Managing Resources and Applications with Hadoop YARN. Big Data Technologies and Databases: Nosql: Introduction to Nosql - Features and Types- Advantages & Disadvantages - Application of Nosql.

Unit IV **[13 hours]**

New SQL: Overview Of New SQL - Comparing SQL, Nosql and NewSQL. Mongo DB: Introduction – Features – Data Types – Mongo DB Query Language – CRUD Operations – Arrays – Functions: Count – Sort – Limit – Skip – Aggregate – Map Reduce. Cursors – Indexes – Mongo Import – Mongo Export.

Unit V **[12 hours]**

Cassandra: Introduction – Features – Data Types – CQLSH – Key Spaces – CRUD Operations – Collections – Counter – TTL – Alter Commands – Import and Export – Querying System Tables.

Suggested Readings:

Seema Acharya and Subhashini Chellappan, "*Big Data and Analytics*", Wiley India Pvt. Ltd., 2016.
Mike Frampton, "*Mastering Apache Spark*", Packt Publishing, 2015.

References:

Tom White, "*Hadoop: The Definitive Guide*", O"Reilly, 4th Edition, 2015.
Mohammed Guller, "*Big Data Analytics with Spark*", Apress, 2015
Donald Miner, Adam Shook, "*Map Reduce Design Pattern*", O"Reilly, 2012

Course Code : **BCS802** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **FREE OPEN-SOURCE SOFTWARE (FOSS)**

Course Objectives:

- To introduce different free and open-source software.
- Exposure to the context and operation of free and open-source software (FOSS) communities and associated software projects.
- To understand intellectual property rights and licensing for FOSS, GPL etc.

Learning Outcomes:

After completion of the course, students will be able to

- Install and run open-source operating systems.
- Gather information about Free and Open-Source Software projects from software releases and from sites on the internet.
- Build and modify one or more FOSS packages and contribute software to and interact with FOSS development projects.

Course Outline:

Unit I **[12 hours]**

Introduction To Open-Source: Open Source, Need and Principles Of OSS, Open-Source Standards, Requirements for Software, OSS Success, Free Software, Examples, Licensing, Free Vs. Proprietary Software, Free Software Vs. Open-Source Software, Public Domain. History Of Free Software, Proprietary Vs Open-Source Licensing Model, Use of Open- Source Software, FOSS Does Not Mean No Cost. History: BSD, The Free Software Foundation, and the GNU Project.

Unit II **[12 hours]**

Open-Source Principles and Methodology: Open-Source History, Open- Source Initiatives, Open Standards Principles, Methodologies, Philosophy, Software Freedom, Open-Source Software Development, Licenses, Copyright Vs. Copy Left, Patents, Zero Marginal Cost, Income-Generation Opportunities, Internationalization. Licensing: What Is a License, How to Create Your Own Licenses, Important FOSS Licenses (Apache, BSD, PL, LGPL), Copyrights and Copy Lefts, Patent.

Unit III **[12 hours]**

Open-Source Projects: Starting and Maintaining Own Open-Source Project, Open-Source Hardware, Open-Source Design, Open-Source Teaching, Opensource Media.

Collaboration: Community And Communication, Contributing to Open- Source Projects Introduction to GitHub, Interacting with The Community on GitHub, Communication, And Etiquette, Testing Open-Source Code, Reporting Issues, Contributing Code. Introduction To Wikipedia.

Unit IV **[12 hours]**

Open-Source Ethics and Social Impact: Open Source Vs. Closed Source, Open-Source Government, Ethics of Open-Source, Social and Financial Impacts of Open-Source Technology, Shared Software, Shared Source, Open Source as A Business Strategy.

Unit V **[12 hours]**

Understanding Open-Source Ecosystem: Open-Source Operating Systems: GNU/Linux, Android, Free BSD, Open Solaris. Open-Source Hardware, Virtualization Technologies, Containerization Technologies: Docker, Development Tools, Ides, Debuggers, Programming Languages, LAMP, Open-Source Database Technologies.
Case Studies: Example Projects: Apache Web Server, BSD, GNU/Linux, Android, Mozilla (Firefox), Wikipedia, Drupal, WordPress, Git, GCC, GDB, GitHub, Open Office, LibreOffice.

Suggested Readings:

Kailash Vadera & Bhavyesh Gandhi, "*Open-Source Technology*," University Science Press, Laxmi Publications, 1st Edition, 2009.
Fadi P. Deek and James A. M. McHugh, "*Open-Source Technology and Policy*," Cambridge University Press, 1st Edition, 2008.

References:

Clay Shirky and Michael Cusumano, "*Perspectives on Free and Open-Source Software*," MIT press, 1st Edition, 2007.
Andrew M. St. Laurent, "*Understanding Open Source and Free Software Licensing*," O'Reilly Media, 1st Edition, 2004.
Dan Woods, Gautam Guliani, "*Open Source for the Enterprise*," O'Reilly Media, 1st Edition, 2005.
Linux kernel Home: http://kernel.org4
Open-Source Initiative: https://opensource.org/5
The Linux Foundation: https://www.linuxfoundation.org/
The Linux Documentation Project: http://www.tldp.org/2
Docker Project Home: http://www.docker.com3.
Linux Documentation Project: http://www.tldp.org/6
GitHub: https://help.github.com/9.

Course Code : **BCS802** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **SOFTWARE TESTING**

Course Objectives:

- To learn and understand the tools and techniques of software testing and its practice in the industry.
- To be aware of the differences between the various testing strategies.
- To know the taxonomy and purpose of software testing tools.

Learning Outcomes:

After completion of the course, students will be able to

- Test a process for continuous quality improvement
- Generate test cases from requirements
- Analyze the modeling techniques: UML: FSM and State charts, combinatorial design etc.
- Test generation from models.

Course Outline:

Unit I **[10 hours]**

Introduction: Purpose of Testing, Dichotomies, Model for Testing, Consequences of Bugs, Taxonomy of Bugs

Unit II **[14 hours]**

Flow Graphs and Path Testing: Basics Concepts of Path Testing, Predicates, Path Predicates and Achievable Paths, Path Sensitizing, Path Instrumentation, Application of Path Testing. Transaction Flow Testing: Transaction Flows, Transaction Flow Testing Techniques. Dataflow Testing: Basics Of Dataflow Testing, Strategies in Dataflow Testing, Application of Data Flow Testing.

Unit III **[12 hours]**

Domain Testing: Domains And Paths, Nice & Ugly Domains, Domain Testing, Domains and Interfaces Testing, Domains and Testability.

Unit IV **[12 hours]**

Paths, Path Products and Regular Expressions: Path Products & Path Expression, Reduction Procedure, Applications, Regular Expressions & Flow Anomaly Detection. Logic Based Testing: Overview, Decision Tables, Path Expressions, Kv Charts, Specifications.

Unit V **[12 hours]**

State, State Graphs and Transition Testing: State Graphs, Good & Bad State Graphs, State Testing, Testability Tips. Graph Matrices and Applications: Motivational Overview, Matrix of Graph, Relations, Power of A Matrix, Node Reduction Algorithm, Building Tools.

Suggested Readings:

Boris Beizer, "*Software Testing techniques*," Dreamtech publishers, 2nd Edition, 2008.
Glenford J. Meyers, "*Art of Software Testing*," Wiley, 3rd Edition, 2011.

References:

Brian Marick, "The craft of software testing," Prentice Hall Series, 1st Edition, 1994
Edward Kit, "*Software Testing in the Real World*", Wesley, 1994.
Perry, "*Effective methods of Software Testing",* John Wiley, 3rd Edition, 2006.

Course Code : **BCS802** Course Type : **Elective** No. of Credits : **4** No. of Hours : **60**	Course Title **INTRODUCTION TO WIRELESS SENSOR NETWORKS**

Course Objectives:

- Understand the fundamental principles and concepts of wireless sensor networks (WSNs), including architecture, protocols, and design considerations.
- Explore the various types of wireless sensor devices, their functionalities, and their applications in real-world scenarios.

Learning Outcomes:

After completion of the course, students will be able to

- Understand the challenges, design goals and architecture of Wireless sensor networks
- Demonstrate a comprehensive understanding of the architecture and operation of wireless sensor networks, including networking protocols, communication models, and data management techniques.
- Analyze the challenges and emerging trends in wireless sensor networks, such as energy efficiency, security, and scalability, and develop strategies to address these issues.

Course Outline:

Unit I **[12 hours]**

Overview Of WSN: Introduction, Brief Historical Survey of Sensor Networks, And Background of Sensor Network Technology, Ah-Hoc Networks, Applications of Wireless Sensor Networks: Sensor and Robots, Reconfigurable Sensor Networks, Highway Monitoring, Military Applications, Civil and Environmental Engineering Applications, Wildfire Instrumentation, Habitat Monitoring, Another Taxonomy of WSN Technology, Basic Sensor Network Architectural Elements, Home Control, Medical Applications.

Unit II **[12 hours]**

Routing Protocols For Ad Hoc Wireless Networks: Designing Issues, Classification of Routing Protocols, Table Driven Routing Protocols, On Demand Routing Protocol, Hybrid Routing Protocol, Hierarchical Routing Protocols.

Unit III **[12 hours]**

System Architecture & Design Issues: Design Constraints for Routing in Wireless Sensor Networks, Classification of Routing Protocols In Wireless Sensor Networks-Hierarchy Role Of Nodes In The Network, Data Delivery Model, Optimization Techniques For Routing In Wireless Sensor Networks.

Unit IV **[12 hours]**

Routing Protocols For WSN: Introduction, Data Dissemination and Gathering, Routing Challenges and Design Issues in Wireless Sensor Networks Network Scale and Time-Varying Characteristics, Resource Constraints, Sensor Applications Data Models, Routing Strategies in Wireless Sensor Networks: WSN Routing Techniques, Flooding, And Its Variants.

Unit V **[12 hours]**

Transport Layer Security Protocols for Designing Issues, Classification of Transport Layer Solutions, Feedback-Based TCP, TCP Bus, Ad Hoc TCP, Security In Ad Hoc Wireless Networks, Issues and Challenges in Security Provisioning, Key Management, Secure Routing In Ad Hoc Wireless Networks. Quality Of Service: Issues And Challenges in Providing QoS in Ad Hoc Wireless Networks, Classification of QoS Solutions.

Suggested Readings:

Ibrahiem M.M. El Emary, Ramakrishnan. S, "*Wireless Sensor Networks from Theory to Applications*", CRC Press, 1st Edition, 2013.

Fei Hu, Xiaojun Cao, "*Wireless Sensor Networks Principles and Practice*", CRC Press, 1st Edition, 2010.

References:

Mounir Frikha, "*Ad hoc Networks Routing, Qos and Optimization*", Wiley, 1st Edition, 2013.

Raheem, Beyah, Janise McNair, Cherita Corbett, "*Security in Ad hoc and Sensor Networks*", World Scientific, 2010.

Course Code : **BCS811** Course Type : **Core (Compulsory)** No. of Credits : **12**	Course Title **DISSERTATION**

Objective:

Implement some of the existing techniques and develop some new algorithm/tool and produce meaningful research outputs.

Each student will work on a dissertation to apply the knowledge of Computer Science and Artificial Intelligence for solving a wide variety of real-world problems. Problems may be decided based on literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Relevant tools may be used for demonstrating the results with physical meaning and create necessary research components

Student is required to submit a detailed project report on the selected topic for their project as per the guidelines decided by the department. The project work is to be evaluated through presentations and viva-voce during the semester and final evaluation will be done at the end of the semester as per the guidelines decided by the department from time to time. The candidate shall present/ publish one paper in national/international conference/seminar/journal of repute.

However, candidate may visit research labs/institutions with the due permission of chairperson on recommendation of supervisor concerned.

Four Year B.Sc. (Honours) Computer Science & AI Programme

List of Minor Courses to be offered by the Dept. of Computer Science & AI to our department students and other department Students

Sl. No	Course Code	Course Titles	Total Credits	L	T	P
Semester I						
1.	BCS 111	Fundamentals of AI and Applications	4	3	1	0
Semester II						
2.	BCS 211	Introduction to Machine Learning	4	3	1	0
Semester III						
3.	BCS 311	Introduction to Deep Learning	4	3	1	0
		Semester IV				
4.	BCS 411	Natural Language Processing	4	3	1	0
		Semester V				
5.	BCS 511	Ethics and Social Implications of AI	4	3	1	0
		Semester VI				
6.	BCS 611	Data Analysis and Visualization	4	3	1	0
		Semester VII				
7.	BCS711	**Any one of the below**	4	3	1	0
		Introduction to Reinforcement Learning				
		Speech Recognition Systems				
		Information Retrieval				
8.	BCS712	**Any one of the below**	4	3	1	0
		Computational Intelligence				
		Fundamentals of Generative AI				
		Introduction to Robotics				
		AI in Clinical Information Systems				
Total Minor Courses: 8			**32**	**24**	**8**	**0**

Note:

- Students who have studied Mathematics as one of their subjects in +2, or those who have completed a Vocational Course in Computer Science & Engineering in +2, or who are having basic programming knowledge are desirable to enroll in these minors.
- Minor in AI is offered to B. Sc (Hons) Computer Science students and for other department students.