B. TECH. COURSE STRUCTURE 2021

INFORMATION TECHNOLOGY

Semester I	**Semester II**	**Semester III**	**Semester IV**	**Semester V**	**Semester VI**	**Semester VII**	**Semester VIII**
Computational Thinking through Programming (4 credits (3L + 0T +1P))	Data Structures (4 credits (3L + 0T +1P))	Software Engineering (4 credits (3L + 0T +1P))	Compiler Design (3 credits (3L + 0T + 0P))	Foundations of Cryptography (3 credits (3L + 0T + 0P))	Techno-Entrepreneurship (4 credits (4L + 0T + 0P))	Elective III (4 credits)	Major Project (20 credits)
Database Management System (4 credits (3L + 0T + 1P))	Object Oriented Programming & System Design (4 credits (3L + 0T +1P))	Theory of Automata (3 credits (3L + 0T + 0P))	Mathematics for CS I (Discrete Mathematics) (3 credits (3L + 0T + 0P))	Cloud Computing (3 credits (3L + 0T + 0P))	Elective II (4 credits)	Elective IV (4 credits)	
System Programming & Scripting (4 credits (3L + 0T + 1P))	Computer Organization & Architecture (4 credits (4L + 0T + 0P))	Data Communications (3 credits (3L + 0T + 0P))	Operating System (4 credits (3L + 0T + 1P))	Computer Graphics (4 credits (3L + 0T + 1P))	Mini Project-I (6 credits)	Professional Ethics (2 credits (2L + 0T + 0P))	
Web Design & Application Development-I (4 credits (2L + 0T + 2P))	Web Design & Application Development-II (4 credits)	Probability and Statistics for CS (3 credits (3L + 0T + 0P))	Computer Networks (4 credits (3L + 0T + 1P))	Soft Computing (4 credits (3L + 0T + 1P))	Industrial Training/Internship (6 credits)	Mini Project-II (10 credits)	
Professional Communication - I (3 credits (3L + 0T + 0P))	Professional Communication - II (3 credits (3L + 0T + 0P))	Design Analysis and Algorithm (4 credits (3L + 0T + 1P))	Advanced Programming Language (4 credits (3L + 0T + 1P))	Elective I (4 credits)			
Sports - I (1 credits)	Sports - II (1 credits)	Competitive Coding - I (2 credits (0L + 0T + 2P))	Competitive Coding - II (2 credits (0L + 0T + 2P))	Competitive Coding - II (2 credits (0L + 0T + 2P))			
		Sports - III (1 credits)					
20	20	20	20	20	20	20	20

COMPUTER SCIENCE

Semester I	**Semester II**	**Semester III**	**Semester IV**	**Semester V**	**Semester VI**	**Semester VII**	**Semester VIII**
Computational Thinking through Programming (4 credits (3L + 0T +1P))	Data Structures (4 credits (3L + 0T +1P))	Software Engineering (4 credits (3L + 0T +1P))	Compiler Design (3 credits (3L + 0T + 0P))	Foundations of Cryptography (3 credits (3L + 0T + 0P))	Techno-Entrepreneurship (4 credits (4L + 0T + 0P))	Elective III (4 credits)	Major Project (20 credits)
Database Management System (4 credits (3L + 0T + 1P))	Object Oriented Programming & System Design (4 credits (3L + 0T +1P))	Theory of Automata (3 credits (3L + 0T + 0P))	Mathematics for CS I (Discrete Mathematics) (3 credits (3L + 0T + 0P))	Machine Learning (4 credits (3L + 0T + 1P))	Elective II (4 credits)	Elective IV (4 credits)	
System Programming & Scripting (4 credits (3L + 0T + 1P))	Computer Organization & Architecture (4 credits (4L + 0T + 0P))	Data Communications (3 credits (3L + 0T + 0P))	Operating System (4 credits (3L + 0T + 1P))	Computer Graphics (4 credits (3L + 0T + 1P))	Mini Project-I (6 credits)	Professional Ethics (2 credits (2L + 0T + 0P))	
Web Design & Application Development-I (4 credits (2L + 0T + 2P))	Web Design & Application Development-II (4 credits)	Probability and Statistics for CS (3 credits (3L + 0T + 0P))	Computer Networks (4 credits (3L + 0T + 1P))	Elective I (4 credits)	Industrial Training/Internship (6 credits)	Mini Project-II (10 credits)	
Professional Communication - I (3 credits (3L + 0T + 0P))	Professional Communication - II (3 credits (3L + 0T + 0P))	Design Analysis and Algorithm (4 credits (3L + 0T + 1P))	Advanced Programming Language (4 credits (3L + 0T + 1P))	Mathematics for CS II (Linear Algebra + Calculus) (3 credits)(3L + 0T + 0P)			
Sports - I (1 credits)	Sports - II (1 credits)	Competitive Coding - I (2 credits (0L + 0T + 2P))	Competitive Coding - II (2 credits (0L + 0T + 2P))	Competitive Coding - III (2 credits (0L + 0T + 2P))			
		Sports - III (1 credits)					
20	20	20	20	20	20	20	20

COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE

Semester I	Semester II	Semester III	Semester IV	Semester V	Semester VI	Semester VII	Semester VIII
Computational Thinking through Programming (4 credits (3L + 0T +1P))	Data Structures (4 credits (3L + 0T +1P))	Software Engineering (4 credits (3L + 0T +1P))	Compiler Design (3 credits (3L + 0T + 0P))	Machine Learning (4 credits (3L + 0T + 1P))	Techno-Entrepreneurship (4 credits (4L + 0T + 0P))	Elective II (4 credits)	Major Project (20 credits)
Database Management System (4 credits (3L + 0T + 1P))	Object Oriented Programming & System Design (4 credits (3L + 0T +1P))	Theory of Automata (3 credits (3L + 0T + 0P))	Mathematics for CS I (Discrete Mathematics) (3 credits (3L + 0T + 0P))	Artificial Intelligence (4 credits (3L + 0T + 1P))	Deep Learning (4 credits (3L + 0T + 1P))	Elective III (4 credits)	
System Programming & Scripting (4 credits (3L + 0T + 1P))	Computer Organization & Architecture (4 credits (4L + 0T + 0P))	Data Communications (3 credits (3L + 0T + 0P))	Operating System (4 credits (3L + 0T + 1P))	Elective-I (3 credits (3L + 0T + 0P))	Mini Project-I (6 credits)	Professional Ethics (2 credits (2L + 0T + 0P))	
Web Design & Application Development-I (4 credits (2L + 0T + 2P))	Web Design & Application Development-II (4 credits)	Probability and Statistics for CS (3 credits (3L + 0T + 0P))	Computer Networks (4 credits (3L + 0T + 1P))	Mathematics for CS II (Linear Algebra + Calculus) (3 credits (3L + 0T + 0P))	Industrial Training/Internship (6 credits)	Mini Project-II (10 credits)	
Professional Communication - I (3 credits (3L + 0T + 0P))	Professional Communication - II (3 credits (3L + 0T + 0P))	Design Analysis and Algorithm (4 credits (3L + 0T + 1P))	Advanced Programming Language (4 credits (3L + 0T + 1P))	Computer Graphics (4 credits)(3L + 0T + 1P)			
Sports - I (1 credits)	Sports - II (1 credits)	Competitive Coding - I (2 credits (0L + 0T + 2P))	Competitive Coding - II (2 credits (0L + 0T + 2P))	Competitive Coding - III (2 credits (0L + 0T + 2P))			
		Sports - III (1 credits)					
20	20	20	20	20	20	20	20

COMPUTER SCIENCE & BUSINESS

Semester I	**Semester II**	**Semester III**	**Semester IV**	**Semester V**	**Semester VI**	**Semester VII**	**Semester VIII**
Computational Thinking through Programming (4 credits (3L + 0T +1P))	Data Structures (4 credits (3L + 0T +1P))	Software Engineering (4 credits (3L + 0T +1P))	Compiler Design (3 credits (3L + 0T + 0P))	Business Economics (4 credits (4L + 0T + 0P))	Techno-Entrepreneurship (4 credits (4L + 0T + 0P))	Elective III (4 credits)	Major Project (20 credits)
Database Management System (4 credits (3L + 0T + 1P))	Object Oriented Programming & System Design (4 credits (3L + 0T +1P))	Theory of Automata (3 credits (3L + 0T + 0P))	Mathematics for CS I (Discrete Mathematics) (3 credits (3L + 0T + 0P))	Machine Learning (4 credits (3L + 0T + 1P))	Elective II (4 credits)	Elective IV (4 credits)	
System Programming & Scripting (4 credits (3L + 0T + 1P))	Computer Organization & Architecture (4 credits (4L + 0T + 0P))	Data Communications (3 credits (3L + 0T + 0P))	Operating System (4 credits (3L + 0T + 1P))	Elective I (4 credits (4L + 0T + 0P))	Mini Project-I (6 credits)	Professional Ethics (2 credits (2L + 0T + 0P))	
Web Design & Application Development-I (4 credits (2L + 0T + 2P))	Web Design & Application Development-II (4 credits)	Probability and Statistics for CS (3 credits (3L + 0T + 0P))	Computer Networks (4 credits (3L + 0T + 1P))	Business Decision Making (3 credits (3L + 0T + 0P))	Industrial Training/Internship (6 credits)	Mini Project-II (10 credits)	
Professional Communication - I (3 credits (3L + 0T + 0P))	Professional Communication - II (3 credits (3L + 0T + 0P))	Design Analysis and Algorithm (4 credits (3L + 0T + 1P))	Advanced Programming Language (4 credits (3L + 0T + 1P))	People Management (3 credits (3L + 0T + 0P))			
Sports - I (1 credits)	Sports - II (1 credits)	Competitive Coding - I (2 credits (0L + 0T + 2P))	Competitive Coding - II (2 credits (0L + 0T + 2P))	Competitive Coding - III (2 credits (0L + 0T + 2P))			
		Sports - III (1 credits)					
20	20	20	20	20	20	20	20

1 credit for 1 hour theory, 1 credit for 1 hour tutorial, 1 credit for 2 hours lab per week

Abbreviations: L - Lecture, T - Tutorial, P - Practical

Pool of Electives

Algorithmic Graph Theory	Algo Trading	Artificial Intelligence (AI)
AI for IoT	Big Data Analytics	Blockchain and Cryptocurrency
Business Analytics	Complexity Theory	Computational Algebra and Number Theory
Computer Music	Cyber Security	Data Mining and Warehousing
Deep Learning	Digital Business Strategy	Digital Product Development
Distributed Systems	E-Business and Digital Economy	Game Theory
Game Development	Global Business and Economy	Image and Vision Processing
Information and Coding Theory	Innovation and Design Thinking	Intelligent Agents and Planning
Internet of Things	Machine Learning	MongoDB
Natural Language Processing	Network Security	Numerical Linear Algebra
Organizational Behavior	Reinforcement Learning	Quantum Computing
Soft Computing	Economic and Financial Analysis	

FIRST SEMESTER

Indian Institute of Information Technology, Lucknow

भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Computer Science

Semester: I

Course Code: CTP1301C

Course Name: Computational Thinking through Programming

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The objective of this course is to grow the computational thinking and problem solving ability of students. Moreover, the aim of this subject is to create various programming concepts such as inputs/outputs, variables, control statements, functions, arrays, pointers, structures, etc. For coding or writing the programs, syntaxes of C language will be taught.

Pre-Requisites: No prior programming experience is assumed. However, logical and rational maturity at the level of a first year engineering or science undergraduate is assumed.

Description

- **Introduction to Digital Computer and Programming (2 hours):** Basic components of computer, binary representation, bits and bytes, program, software.
- **Introduction to Computational Thinking (2 hours):** Procedural computational approach to real life problems, idea of algorithms, creating flowcharts and pseudo-code.
- **Introduction to Computational Problem Solving through C (2 hours):** Programming language concepts and its applicability on problem solving, introducing C programming language, inputs and outputs, compiling and running C program
- **C Fundamentals (4 hours):** C character set, identifiers and keywords, data type, consonants, declarations, operators (arithmetic, relational, logical, assignment, unary, bitwise, etc.).

- **Control Statements (4 hours):** Branching: if-else, Looping: while, do-while, for, nested control, switch, break, continue, goto.
- **Functions (4 hours):** Defining a function, accessing a function, function prototypes, argument passing, recursion.
- **Variables (3 hours):** variable and their scopes, automatic, external/global, static variables.
- **Arrays (4 hours):** Defining an array, processing arrays, passing arrays to functions, multi-dimensional arrays.
- **Pointers (4 hours):** defining pointers, passing pointers to functions, dynamic memory allocation, operations on pointers, arrays of pointers call by value vs. call by reference.
- **Structure and Unions (3 hours):** Defining and processing a structure, user defined data types, structures and pointers, passing structure to functions, self-referential structures, Unions.
- **Data Files (3 hours):** File handling, multi-file programming.
- **String (2 hours):** Defining and processing string. Various operations on string.
- **Program analysis (1 hour):** Debugging programs with gdb, memory analysis using valgrind.
- **Capstone Project (2 hours):** A capstone project using majority of the above modules.

Laboratory Experiments:

Implementation of all the above modules covered in theory through C programming.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Computationally think and analyze a real-life problem.
- Write pseudo codes and corresponding program in C for a undertaken project.
- Comprehend the logic and procedural flow of a program.
- Acquire knowledge various syntaxes and concepts of C programming.
- Undertake some advanced courses, e.g., Algorithms, Advanced Programming Languages, etc.

Contact Details: Dr. Chandranath Adak, Department of Computer Science, IIITL, chandra@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Byron Gottfried, *Schaum's Outline: of Programming with C*, 4th Edition, McGraw-Hill, 2018.

2. E. Balaguruswamy, *Programming in ANSI C*, 8th Edition, Tata McGraw-Hill, 2019.

- **References**

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Second Edition, Prentice Hall of India, 1988.
2. Herbert Schildt, *C: The Complete Reference*, 4th Edition, McGraw Hill Education, 2017.

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Department of CS/IT/CS-AI/CSB

Semester: I

Course Code: DMS1301C

Course Name: Database Management System

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The objective of this course is to develop the understanding of the fundamentals of relational database systems. This course will help students to learn how to construct databases using DBMS products, such as MySQL/Oracle/My SQL Server. Design database systems and understand new developments and trends in databases.

Pre-Requisites: No prior programming experience is assumed. However, logical and rational maturity at the level of a first year engineering or science undergraduate is assumed.

Description

- **Introduction (6 Hours):** Data, data processing requirement, desirable characteristics of an ideal data processing system, traditional file based system, its drawback, concept of data dependency, Definition of database, database management system, 3-schema architecture, database terminology, benefits of DBMS.
- **Relational Database (6 Hours):** Relational data model: Introduction to relational database theory: definition of relation, keys, relational model integrity rules.
- **Database Analysis (8 Hours):** Conceptual data modeling using E-R data model -entities, attributes, relationships, generalization, specialization, specifying constraints, Conversion of ER Models to Tables, Practical problems based on E-R data model.

- **Relational Database Design (7 Hours):** Normalization- 1NF, 2NF, 3NF, BCNF, 4NF and 5NF. Concept of Denormalization and practical problems based on these forms.
- **Transaction Management and Concurrency control (7 Hours):** Concept of Transaction, States of Transaction and its properties, Need of Concurrency control, concept of Lock, Two phase locking protocol.
- **Recovery Management (6 Hours):** Need of Recovery Management, Concept of Stable Storage, Log Based Recovery Mechanism, Checkpoint.

Laboratory Experiments:

Students will perform SQL commands to demonstrate the usage of DDL and DML, joining of tables, grouping of data and will implement PL/SQL constructs.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Analyze the Information Systems as socio-technical systems, its need and advantages as compared to traditional file-based systems.
- Analyze and design database using ER data model by identifying entities, attributes and relationships.
- Apply and create Relational Database Design process with Normalization and Denormalization of data.
- Comprehend the concepts of transaction management, concurrence control and recovery management.
- Demonstrate use of SQL and PL/SQL to implementation database applications.

Contact Details: Dr. Rahul Kumar Verma, Department of Computer Science, IIITL, rahul@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Silverschatz A., Korth F. H. and Sudarshan S., *Database System Concepts*, 6th Edition, Tata McGraw-Hill, 2010.
  2. Elmasri R. and Navathe B. S., *Fundamentals of Database Systems*, 7th Edition, Pearson, 2016.

- **References**

  1. Bayross I., *SQL, PL/SQL the Programming Language of Oracle*, 4th Edition, BPB Publications, 2009.
  2. HofferJ., Venkataraman, R. and Topi, H., *Modern Database Management*, 12th Edition, Pearson, 2016.

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Department of Computer Science

Semester: I

Course Code: WDA1202C

Course Name: Web Design & Application Development

Credits	L	T	P	Section (Group)
4	2	0	2	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

Web Applications are the essential technology in digital communication. Introduction of REST APIs will introduce to the students about the communication between Web Browser and Web Server using structured data. This course will cover the essential protocols and tools required for a hosting and deployment of a Web Application.

Pre-Requisites: Nil

Description

- **Introduction to Internet and Web (4 hours):** Evolutional Historical Journey of Internet and Web, Concepts of WWW (World Wide Web), Client -Server Model, Introduction to Web Browser and Web Servers, Features of Web 2.0 and Web 3.0. HTTP and TCP protocols for data communication, IP Addressing and Port Numbers, Domain Name System (DNS), Uniform Resource Locator (URL), Application Programming Interface (API), Web and Micro Services, Components of Web Hosting. Frontend-Backend Technologies, Introduction to Databases, xml, JSON, REST API formats, Introduction to IDEs.
- **Design of Web Components (2 hours):** Basic principles involved in developing a Website, Planning process, Five Golden rules of Web Designing, Page Design, Home Page Layout, Design Concepts, Concepts of effective Web design, Bandwidth and Cache, Display Resolution, Look and Feel of a Website

- **Frontend Technology Elements (8 hours):** Introduction to HTML, HTML Syntax, Semantic of Markup Language, Structure of HTML Documents, Quick Tour of HTML Elements, HTML5 Semantic Structure Elements. CSS, Bootstrap.
- **Programming with Java Script (JS) (10 hours):** Scripting vs Programming Languages, Introduction to Java Script, Syntactic characteristics of JS, Variables and Data types, Operators, Conditionals, Functions, Arrays, Forms, Events and Event Handling, Objects, Documents.
- **Backend Technology Elements (10 hours):** Introduction of Server-side Programming, introduction of NodeJS, Database Concepts and Web Application connection with Database, Introduction to COM/DCOM Debugging, Testing, Deployment, Hosting, Sessions and Cookies Management.
- **Application Development (8 hours):** Differences among Web, Desktop and Mobile Applications, Introduction to cloud, Develop and Deployment of Web Application.
- **Web Application Security (1 hours):** Web application vulnerabilities, Protection against common Attacks on Web Applications, SSL Certificate.

Lab Assignments:

(i) Display your Curriculum Vitae(cv) detail information with html background and other tags.

(ii) Display your college details with hyperlink and images

(iii) Display election details using table data.

(iv) Build mouse hover elements.

(v) Print friend list and details using javascript

(vi) Design calculator using html css and javascript.

(vii) Design login and SignUp using JavaScript

(viii) Design 10 questions Quiz

(ix) Add database in login and signUp with validation

(x) Project: A hosted website of minimum functionality of 5 pages Home, Gallery, Blog, Contact Us, About Us.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understands the functionalities of Internet and World Wide Web (WWW).
- Build a foundation in HTML5 and the semantics of good coding style.
- Make dynamic Web Applications with JavaScript.
- Understands the deployment process for a Web Application.

- Possible attacks on Web Applications and protection against them

Contact Details: Mr. Prashant Singh (Visiting), Department of Computer Science, IIITL prashant@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Jon Duckett, *HTML & CSS Design and Build Websites*, John Wiley & Sons, 2011.
  2. Thomas A Powell, *HTML & CSS: The Complete Reference*, Fifth Edition, McGraw-Hill, 2010.
  3. David Harmon, *Effective JavaScript: 68 Specific Ways to Harness the Power of JavaScript*, Addison-Wesley Professional, 2012.
  4. Shelley Powers, *Learning Node: Moving to the Server-Side*, 2nd Edition, O'Reilly, 2012.

- **Web Resources**

  1. https://developer.mozilla.org/en-US/
  2. https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference
  3. https://www.freecodecamp.org/
  4. https://www.w3schools.com/
  5. https://devdocs.io/

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भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Management and Humanities

Semester: I

Course Code: PCO1300C

Course Name: Professional Communication I

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The objective of this course is to enhance the overall listening, speaking, writing and reading skills of the students. It aims at building strategies and offers tools for effective communication in professional settings.

Pre-Requisites: Basic Proficiency in English Language

Description

- **Basics of Communication (4 hours):** Overview of Communication, Types of Communication, 7 Cs of Communication, Barriers to Communication, Need for Professional Communication, Role of Professional Communication in Industries, Job Opportunities in Professional Communication
- **Active Listening (6 hours):** Listening Vs Hearing, Types of Listening: Comprehensive Listening, Critical Listening, Appreciative Listening, Empathetic Listening, Barriers to Listening: Information Overload, Personal Concerns, Prejudice, External Distractions, Rate of Speech etc., Steps to Effective Listening, Telephonic Conversation
- **Effective Reading (6 hours):** Comprehension Skills, Skimming, Scanning, Identifying Main Ideas, Understanding Discourse: Speech Act and Pragmatics, Identifying Topic Sentence and Theme in Discourse, Summarizing
- **Effective Writing (20 hours):** Building Blocks of Writing: Objectives, Types, Importance, Format and Structure, Paragraph Writing, Business Letters, Cover Letters and Resume, Email Etiquettes, Report Writing, Writing for Web- Blogs and Wikis

- **Grammar and Vocabulary (6 hours):** Word Formation Process: Suffix, Prefix, Infix, Circumfix, Homophones, Homonyms, Semantic Broadening, Semantic Narrowing, Phrases and Sentences

Learning Outcomes Expected:

After completing the course, the student will be able to:

- comprehend complex texts by employing reading strategies
- express their thoughts in writing effectively by utilizing various techniques, both online and offline
- employ listening strategies for effective communication
- use grammar as a tool in comprehension and creation of oral and written discourse effectively

Contact Details: Dr. Neelu, Department of Management & Humanities, neelu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Raman, M., & Sharma, S. , *Technical communication: Principles and practice*, Oxford University Press, 2015.

- **References**

1. Anderson, P. V, *Communicative English for engineers and professionals*, Pearson Education India, 2010.
2. Mishra, S., & Muralikrishna, C. , *Communication Skills for Engineers*, Pearson Education India, 2011

SECOND SEMESTER

Indian Institute of Information Technology, Lucknow

भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Computer Science

Semester: II

Course Code: COA2400C

Course Name: Computer Organization & Architecture

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech. (CS)

Course Module Details

Objective(s)

- To provide students with basic concepts in computer system as its logic operations.
- To make the students understand the basic operations involved in execution of an instruction.
- Explain the basic concept of interrupts and their usage to implement I/O control and data transfers.
- Identify the different architectural design issues that can affect the performance of a computer such as, RISC architecture, instruction set design, and addressing modes

Pre-Requisites: Fundamentals of Digital Electronics.

Description

- **Basics of Computer Architecture (8 hours):** Number System and code conversion , Logic gates, Flip flops, Registers, Counters, Multiplexer, De-multiplexer, Decoder, Encoder etc.
- **Register Transfer and Micro operations (5 hours) :** Register transfer Language, Register transfer, Bus & memory transfer, Arithmetic micro operations, Logic micro operations, Shift micro operations, Design of ALU.
- **Basic Computer Organization (10 hours):**Instruction codes, Computer instructions, Timing & control, Instruction Cycles, Memory, register, and input-output reference instructions, Interrupts, Complete computer description & design of basic computer.

- **Central Processing Unit (8 hours):** General register organization, Stack organization, Instruction format, Addressing modes, Data transfer & manipulation, Program control, RISC, CISC. Pipe lining and hazards.
- **Computer Arithmetic (2 hours) :** Addition & Subtraction, Multiplication Algorithms, Division algorithms.
- **Memory Unit (4 hours):** Memory hierarchy, Processor vs. memory speed, High-speed memories, Main Memory, Cache memory and mapping schemes, Associative memory, Interleaving, Virtual memory, Memory management techniques.
- **Multiprocessors (3 hours) :** Characteristics of multiprocessors, Interconnection structures, Inter processor arbitration, Inter-processor communication & synchronization. Peripheral devices, I/O interface Data transfer schemes, Program control, Synchronous and asynchronous data transfer, Interrupt, DMA transfer, I/O processor.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Illustrate various elementary concepts of computer architecture including, syntax of register transfer language, micro operations, instruction cycle, and control unit.
- Describe the design of basic computer with instruction formats & addressing modes
- Explore various memory management techniques and algorithms for performing addition, subtraction and division etc.
- Interpret the concepts of pipelining, multiprocessors, and inter processor communication.

Contact Details: Dr. Niharika Anand, Department of Information Technology, IIITL, niharika@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. V. C. Hamacher, Z. G. Veranesic, and S. G. Zaky, Computer Organization, Tata McGraw Hill
  2. E. William Stallings, Computer Organization and Architecture -– Designing for Performance, Pearson Education
- **References**
  1. J. P. Hayes, Computer Architecture and Organisation, McGraw Hill
  2. D.A. Pattersen and J.L. Hennesy, Computer Architecture- A quantitative Approach, Morgan Kaufman

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Department of Computer Science

Semester: II

Course Code: DST2301C

Course Name: Data Structures

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (CS/IT/CSAI/CSB)

Course Module Details

Objective(s)

- To make students develop knowledge of basic data structures for storage and retrieval of ordered or unordered data.
- Choose appropriate searching and sorting techniques and apply graph algorithms for various practical problems.
- Formulate new/improved solutions for programming problems using learned data structure.

Pre-Requisites: Fundamentals of Computer Programming.

Description

- **Module 1 (14 hours):**
  - Introduction to abstract data types, variables, storage types.
  - Introduction to Array, Array representation, Contiguous storage.
  - Linear list (Abstract data type, sequential and linked representations).
  - Linked list (Single Linked list, Doubly Linked list, Circular Linked list).
  - Stack (Parenthesis matching, towers of Hanoi)
  - Queue (Queue, Priority queue).

- **Module 2 (14 hours) :**
  - Introduction to sorting and searching methods.
  - Sorting (Bubble sort, Insertion sort, Selection sort, Radix sort, Merge sort, Quick sort, Heap sort).
  - Searching (Linear search, Binary search, search efficiency, insertion and deletion operations, importance of balancing, AVL trees, Infix, Prefix, Postfix)
- **Module 3 (14 hours):**
  - Introduction to non-linear data structures. Tree (Binary trees and their properties, terminology, sequential and linked implementations, tree traversal methods and algorithms, heaps as priority queues, heap implementation, insertion and deletion operations)
  - Graph (Definition, terminology, directed and undirected graphs, properties, connectivity in graphs, applications, implementation adjacency matrix and linked adjacency chains, graph traversal – breadth first and depth first, spanning trees).
  - Hashing (Search efficiency in lists and skip lists, hashing as a search structure, hash table, collision avoidance, linear open addressing, chains).

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand the strength and weakness of different data structures.
- Use the appropriate data structure in context of solution of given problem.
- Develop programming skills which require to solve given problem.

Contact Details: Dr. Rahul Kumar Verma, Department of Computer Science, IIITL, rahul@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. "Fundamentals of Data Structures in C" by Horowitz, Sahni and Anderson-Freed, 2nd Edition (2008).
  2. "Data Structures Through C in Depth" by S. K. Srivastava and Deepali Srivastava (2011).
  3. "Data Structures, Algorithms, and Applications in C++" by S. Sahani, 2nd Edition (2004).
  4. "Data Structures and Algorithms in Java" by Robert Lafore, 2nd Edition (2003).
- **References**
  1. "Data Structures and Algorithm Analysis in JAVA" by Mark Allen Weiss, 3rd Edition, (2011).
  2. "Data Structures and Algorithms" by V. Aho, J. E. Hopcroft, and J. D. Ullman, 1st edition, (1983).

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Department of Management and Humanities

Semester: II

Course Code: PCO2300C

Course Name: Professional Communication II

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The objective of the course is to build a toolkit of communication skills that will enable students to become an effective communicator. It aims at advancing the soft-skills in students to increase their employability prospects. It prepares them for dealing with stressful situations in their professional career.

Pre-Requisites: Basic Proficiency in English Language

Description

- **Basics of Communication (2 hours):** Overview of Communication, Types of Communication, 7 Cs of Communication, Barriers to Communication, Need for Professional Communication, Role of Professional Communication in Industries, Job Opportunities in Professional Communication
- **Conversation (6 hours):** Creating a Communication Strategy, Introducing Yourself, Networking, Conversation and Dialogues: Starting a Conversation, Ending a Conversation, Telephonic Conversation, How to Handle Difficult Conversations, What to Say and What Not to Say in Crisis Situation
- **Non-Verbal communication (8 hours):** Body Language: Facial Expressions, Posture, Eye Contact, Kinesics, Proxemics, Chronemics, Haptics, Cross-Cultural Communication, Voice Features: Tone, Voice Modulation, Fluency, Rate of Speech, Pitch
- **Effective Speaking (22 hours):** How to Cope with Public Speaking Anxiety, Presentation Skills: Planning, Composition, Review, Oral Presentation, Online Presentation, Interview, Group Communication- Introducing Others, Giving Feedback, Delivering Bad News, Group Discussions.

- **Communicating with People in Stress (4 hours):** Awareness about Psychological Impact of Stress, What People Experience in a High-Stress Environment, Positive Communication: Practicing Empathy, A Good Listener, Reassurance, Follow Up.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- effectively use soft skills in professional settings
- employ communication strategies in situations of crisis
- plan and make effective oral presentations with/ without visual aid
- communicate effectively in high-stress environment

Contact Details: Dr. Neelu, Department of Management & Humanities, neelu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Raman, M., & Sharma, S. , *Technical communication: Principles and practice*, Oxford University Press, 2015.

- **References**

1. Anderson, P. V, *Communicative English for engineers and professionals*, Pearson Education India, 2010.
2. Mishra, S., & Muralikrishna, C. , *Communication Skills for Engineers*, Pearson Education India, 2011
3. Nitin, B. , *Communicative English for engineers and professionals*, Pearson Education India, 2010
4. Farrell, A., & Geist-Martin, P. , *Communicating social health: Perceptions of wellness at work*, Management Communication Quarterly, 18(4), 543-592, 2005

THIRD SEMESTER

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Department of CS/IT

Semester: III

Course Code: TAU3300C

Course Name: Theory of Automata

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT/CS/CS-AI)

Course Module Details

Objective(s)

To learn and understand formal languages, which are essential in compiler design. They are also useful in designing a controller

Pre-Requisites: Discrete Mathematics

Description

- **Regular languages and Finite Automata (16 Hours):** Regular languages: Introduction: Notion of a formal language, DFAs and notion for their acceptance, informal and formal definitions. Class of regular languages, Closure of the class under complementation, union and intersection. Strategy for designing DFAs, Pumping lemma for regular languages, NFAs.Notion of computation trees. Definition of languages accepted. Construction of equivalent DFAs of NFAs. NFAs with epsilon transitions, Regular expressions, Closure properties for regular languages, Myhill-Nerode theorem as characterization of regular languages, States minimization of DFAs.
- **Context free languages and Pushdown Automata (16 Hours):** Notion of grammars and languages generated by grammars. Equivalence of regular grammars and finite automata. Context free grammars and their parse trees. Context free languages. Ambiguity. Pushdown automata (PDAs): deterministic and nondeterministic. Instantaneous descriptions of PDAs. Language acceptance by final states and by empty stack. Equivalence of PDAs and CFGs, Elimination of useless symbols, epsilon productions, unit productions from CFGs. Chomsky normal form, Pumping lemma for CFLs and its use. Closure properties of CFLs, Decision problems for CFLs.

- **Recursively enumerable languages and Turing Machine (10 Hours):** Turing machines, undecidability Informal proofs that some computational problems cannot be solved, Turing machines (TMs), their instantaneous descriptions. Language acceptance by TMs.Church-Turing hypothesis and its foundational implications, Codes for TMs. Recursively enumerable (r.e.) and recursive languages. Existence of non-r.e. languages. Notion of undecidable problems.

Learning Outcomes Expected

After completing the course, the student will be able to:

- Understand formal languages used to describe problems.
- Design formal machines those recognize the formal languages.
- Understand fundamental concepts required to learn compiler design.

Contact Details: Dr. Soumendu Chakraborty, Department of CS, IIITL, soumendu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Michael Sipser *Introduction to the theory of Computation*, Third Edition, Cengage Learning.

- **References**

  1. Peter Linz, *Introduction to Formal Language and Automata*, Fifth Edition, Jones & Bartlett Learning
  2. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, *Introduction to Automata Theory, Languages, and Computations* , Fifth Edition, Third Edition, Prentice Hall, 2006

Department of Mathematics

Semester:III

Course Code: PSC3300C

Course Name: Probability and Statistics for Computer Science

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT,CS,CS-AI, CS-Business)

Course Module Details

Objective(s)

To provide a balanced introduction to probability theory and mathematical statistics along with their applications.

Pre-Requisites: Basics of Linear Algebra.

Description

- **Probability(4 hours):** Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems.
- **Random Variables(5 hours):** Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function, median and quantiles, Chebyshev's inequality, problems.
- **Special Distributions(5 hours):** Discrete uniform, binomial, geometric, negative binomial, hypergeometric, Poisson, continuous uniform, exponential, gamma, normal distributions.
- **Function of a Random Variable(3 hours):** Distribution of function of a random variable, problems.
- **Joint Distributions(5 hours):** Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bivariate normal distribution, problems.
- **Transformations(5 hours):** functions of random vectors, distributions of sums of random variables, problems.

- **Sampling Distributions(4 hours):** The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problems.
- **Estimation(4 hours):** Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, problems.
- **Testing of Hypotheses(5 hours):** Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, the most powerful test and Neyman Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications, problems.

Learning Outcomes Expected:

- Understand the basic principles of probability, different probability distributions of discrete, continuous, joint random variables and their characteristics
- estimation of population parameters from data
- learn the basic components of hypothesis testing and perform various hypothesis tests.

Contact Details: Dr. Mary Samuel, Department of Mathematics, IIITL, marysamuel@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. William W. Hines, Douglas C. Montgomery , David M. Goldsman, Connie M. Borror, *Probability and Statistics in Engineering* ,fourth edition, John Wiley & Sons, 2003.
2. Sheldon M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists* , fifth edition, Academic Press, 2014.
3. Irwin Miller Marylees Miller *John E. Freund's Mathematical Statistics with Applications*, Eighth Edition, Pearson Education Limited, 2014.

- **References**

1. Charles M.Grinstead, J. Laurie Snell, *Introduction to Probability*,second revised edition, American Mathematical Society 1997.
2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, *Probability and Statistics for Engineers and Scientists*, Ninth edition, Pearson 2017.
3. V.K. Rohatgi & A.K. Md. E. Saleh, *An Introduction to Probability and Statistics*, second edition, Wiley , 2001.
4. Alexander Mood, Franklin Graybill, Duane Boes, *Introduction to the Theory of Statistics*,third edition, McGraw-Hill,1974.

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Department of Information Technology

Semester: III

Course Code: DAA3301C

Course Name: Design and Analysis of Algorithms

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS)

Course Module Details

Objective(s)

The designing of algorithm is an important component of computer science and information technology. The objective of this course is to make students aware of various techniques used to evaluate the efficiency of a particular algorithm. Students eventually should learn to design efficient algorithm for a particular program. Analytical skills will be tested and improved.

Pre-Requisites: Data structures

Description

- **Introduction to Algorithm analysis (8 hours) :** Algorithm Design paradigms, motivation, concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations, Insertion sort example, order of growth. Solving Recurrences- substitution method, recursion tree method, master method, Iteration method. Types of solutions, Introduction to Randomized algorithms
- **Divide and conquer approach (6 hours) :** structure of algorithms, building recurrence relations, runtime analysis. Examples- Mergesort, quicksort, Binary search, Strassen's Matrix multiplication
- **Greedy Algorithms (8 hours) :**design technique, greedy choice property, optimal substructure, approximate algorithms. Examples- Coin selection problem, Activity selection problem, Knapsack problem, Travelling salesman problem, minimum cost spanning tree, Single source shortest paths

- **Dynamic Programming (6 hours):** design technique. Examples- Shortest path in graph, chain matrix multiplication, Traveling salesman Problem, longest Common sequence problem, knapsack problem
- **Graphs and Trees (3 hours) :** Overview, Representation, Types, Problem formulation and conversion, Traversal methods and their analysis
- **Back tracking (3 hours) :** Overview, DFS, 8-queen problem and Knapsack problem
- **Branch and bound (3 hours) :** Overview, BFS, LC and FIFO. Examples- 0/1 Knapsack problem, Traveling Salesman Problem
- **Computational Complexity (3 hours) :** Complexity measures- P, NP, NP-H, NP-C complexity classes. Examples- SAT, TSP etc.

Lab Exercises:

The lab programs will be solve by using C/C++ Programming Language. For all the practicals, students will have to present the complexity analysis in best, worst and average cases

- Implementation of Linear search method
- Implementation of Recursive binary search method
- Implementation of Recursive Quicksort method
- Implementation of Coin selection problem using Greedy approach
- Implementation of Fractional Knapsack problem using Greedy approach
- Implementation of 0/1 Knapsack problem using Dynamic approach
- Implementation of LCS using Dynamic approach
- Implementation of n-Queen's problem using Backtracking approach
- Develop a Hamiltonian Path in an undirected graph is a path that visits each vertex exactly once. A Hamiltonian cycle (or Hamiltonian circuit) is a Hamiltonian Path such that there is an edge (in graph) from the last vertex to the first vertex of the Hamiltonian Path. Develop a program to implement the solution of Travelling Salesman Problem by considering the Hamiltonian cycle approach.
- A road network can be considered as a graph with positive weights. The nodes represent road junctions and each edge of the graph is associated with a road segment between two junctions. The weight of an edge may correspond to the length of the associated road segment, the time needed to traverse the segment or the cost of traversing the segment. Using directed edges it is also possible to model one-way streets. Such graphs are special in the sense that some edges are more important than others for long distance travel (e.g. highways). This property has been formalized using the notion of highway dimension. There are a great number of algorithms that exploit this property and are t herefore able to compute the shortest path a lot quicker than would be possible on general graphs. Develop a program to find the shortest path from each node to solve the road network problem.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Apply knowledge of mathematics, science, engineering and computing appropriate to the discipline.
- Analyze a problem, and identify and define the computing requirements appropriate to its solution.
- Design, implement, and evaluate a computer-based system, process, component, or programmer to meet desired needs
- Use current techniques, skills, and tools necessary for computing practice

Contact Details: 1.Dr. Deepshikha Agarwal, Department of Information Technology, IIITL, deepshikha@iiitl.ac.in

2.Dr. Vishal Krishn Singh, Department of Computer Science, IIITL, vks@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. T. H. Cormen, Leiserson, Rivest and Stein, *Introduction of Computer algorithm* , PHI Publication
  2. E. Horowitz, S. Sahni, and S. Rajsekaran, *Funadmentals of Computer Algorithms*, Universities Press

- **References**

  1. Sara Basse, A. V. Gelder, *Computer Algorithms*, Addison Willey Publication
  2. J.E Hopcroft, J.D Ullman, *Design and analysis of algorithms*, TMH Publication
  3. D. E. Knuth, *The art of Computer Program*, PHI Publication

FOURTH SEMESTER

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Department of Computer Science

Semester: IV

Course Code: CDE4301C

Course Name: Compiler Design

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

To learn the different phases of compiler design. To understand the core concepts involved in different phases of design.

Pre-Requisites: Discrete Mathematics, Theory of Automata, Data Structures

Description

- **Unit 1 (9 hours):** Language processors, Compiler structure: analysis-synthesis model of compilation, various phases of compiler, grouping of phases into passes and Other basic concepts related to compilers such as Interpreters, Pre-processors, Macros etc., A model of a compiler front end, Compiler construction tools and Applications of compiler technology.
- **Unit 2 (9 hours):** Syntax definition: definition of grammars, derivations, parse trees, ambiguity, Associativity of operators, Precedence of operators, Syntax-Directed Translation: Postfix Notation, Synthesized Attributes, Simple Syntax-Directed Definitions, Tree Traversals. Parsing: Top-Down and Bottom-up Parsing, designing a Predictive Parser, and Left Recursion.
- **Unit 3 (9 hours):** The Role of the Lexical Analyzer, Specification of Tokens, Recognition of Tokens: Transition Diagrams and Recognition of Reserved Words and Identifiers, The Lexical - Analyzer Generator Lex: Use of Lex, Structure of Lex Programs and Conflict Resolution in Lex, Finite Automata: Nondeterministic Finite Automata, Transition Tables, Acceptance of Input Strings by Automata, Deterministic Finite Automata, From Regular Expressions to Automata: Conversion of an NFA to a DFA, Simulation of an NFA, and Construction of an NFA from a Regular Expression.

- **Unit 4 (9 hours):** Introduction to Syntax Analysis, Context-Free Grammars, writing a Grammar: Eliminating Ambiguity, Elimination of Left Recursion, Left Factoring, Top-Down Parsing: Recursive-Descent Parsing, FIRST and FOLLOW, and LL(l) Grammars, Bottom-Up Parsing: Reductions, Handle Pruning, Shift-Reduce Parsing, and Conflicts during Shift-Reduce Parsing, Introduction to LR Parsing: Simple LR, LR (1) and LALR (1) parsing.
- **Unit 5 (9 hours):** Semantic Analysis and Syntax Directed Translation, Symbol Table Design: Function of Symbol Table (ST), Information provided by ST, Attributes of ST, Data Structures for ST: Unsorted list, sorted list, linked list, search trees, Hash table; Scoping, Methods to deal with Scope. Intermediate Code Generator: High-level and Low-level Intermediate representation, Syntax tree & DAG representations, Three-address code, Code Optimization: Criteria for code improving transformation, Basic blocks, Flow graph.

Learning Outcomes Expected:

After learning this course the learners will be able to understand

- Lexical analysis and parsing meant for analyzing the grammar of the language.
- Need and designing of the syntax table.
- Syntax directed definition and syntax directed translation.
- Intermediate code generation from syntax tree.

Contact Details: Dr. Soumendu Chakraborty, Department of Computer Science, IIITL, soumendu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. A.V. Aho, M.S. Lam, R. Sethi & J.D. Ullman, *Compilers: Principles, Techniques and Tools*, Second Edition, Pearson, 2007.

- **References**

1. K.C. Louden, *Compiler Construction: Principles and Practice*, Course Technology Inc, 1997.

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Department of Information Technology

Semester: IV

Course Code: CNE4301C

Course Name: Computer Networks

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS)

Course Module Details

Objective(s)

After completing this course student will be able to understand the basic components of Networking. The ultimate goal of this course is to make the students apply the knowledge to design the future applications e.g. IoT. The subject will cover major protocols, their working and in-depth discussion of each topic alongwith practical implementation.

Pre-Requisites: Fundamentals of Computers

Description

- **Introduction (10 hours) :** Computer Network-Requirement, Benefits, Challenges, Reference models : OSI & TCP/IP. Components, Transmission media, Topologies, Types-LAN, WAN, MAN, PAN. Fundamentals of communication- Bit rate, baud rate, bandwidth, Nyquist rate, A/D conversions. Example networks- ARPANET, PSTN, Satellite communication, Mobile telephone system. Internetworking devices- Router, gateway, bridge, hub, switch, amplifiers
- **Data Link Layer (8 hours) :** Header and payload, design issues, Framing, Addressing, Flow control, Error control, Medium access control- static/dynamic, data link protocols, sliding window protocols, example of data link protocols – HDLC, PPP Access
- **Network Layer (10 hours) :** design issues, Routing- principle of optimality, static/dynamic. Routing protocols- Dijikstra's algo, Bellmanford, DVR- mechanism and issues, LSR, Hierarchial routing, , multicast routing, congestion control algorithm. Logical addressing- IPv4, IPv6,CIDR, subnetting, supernetting. Protocols- IP, ICMP, ARP, RARP, DHCP

- **Transport Layer (8 hours):** design issues, port addressing, segmentation and reassembly, reliable/unreliable service, congestion control, error control, flow control, Protocols-TCP, UDP. WLANs, Mobile IP.
- **Application Layer (4 hours)- :** Domain name system, E-mail, World wide web, HTTP, SMTP, TELNET, FTP

Lab Exercises:

Lab will be conducted on Cisco Packet Tracer, Wireshark and Turbo C.

- Implementation of Parity error detection method
- Implementation of Hamming error correction method
- Use of config, ping, traceroute command in windows/ Unix
- To observe TCP packets using Wireshark
- To observe UDP packets using Wireshark
- To observe HTTP packets using Wireshark
- To observe ICMP packets using Wireshark
- IPv4 Address Subnetting- When given an IP address, network mask, and subnetwork mask, you will be able to determine other information about the IP address such as: Class of address, Network id , host id, subnet id, calculate network address and broadcast address
- Perform basic router / switch configuration in Cisco Packet tracer
- Perform basic subnetting in Cisco packet tracer

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Plan and effectively build simple LANs
- Deploy and effectively perform basic configurations for routers and switches
- Implement the IP addressing schemes
- Describe the key components and technologies related to internet

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2.Dr. Brijesh Chaurasia, Department of Information Technology, IIITL, brijesh@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Andrews S. Tanenbaum, *Computer Networks* , Pearson Education
2. Behrouz Forouzan, *Data Communications and Networking*, Tata McGraw-Hill
3. Alberto Leon-Garcia, Indra Widjaja, *Communication Networks: Fundamental Concepts and Key Architectures* ,McGraw-Hill
4. Larry L. Peterson, Bruce S. Davie, *Computer Networks A Systems Approach* , Elsevier Science

- **References**

1. William Stalings, *Computer Communication Networks*, Prentice Hall
2. William Shay, *Understanding Data Communications & Networks*, Cengage learning
3. CISCO, *Cisco Networking Academy Programme CCNA 1 & 2 Companion Guide*, Pearson Education
4. CISCO, *Cisco Networking Academy Programme CCNA 1 & 2 Lab Companion*, Pearson Education

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Department of Mathematics

Semester: IV

Course Code: MCS4300C

Course Name: Mathematics for CS I (Discrete Mathematics)

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

Discrete Mathematics is the study of discrete/distinct structures/objects in nature.This course provides the mathematical basis for the understanding of computers and modern computation. This course serves more than one purpose. After successful completion of this course, students should learn a particular set of mathematical facts and how to apply them; more importantly, this course should teach students how to think logically and mathematically. This course stresses mathematical reasoning and the different ways problems are solved. It is the backbone of computer science and has a lot of applications in cryptography and engineering.

Pre-Requisites: Nil

Description

- **Logic, Proofs, and Counting (4 hours):** Propositional Logic, Direct Proof, Proof by Contradiction, Proof by Contrapositive, Constructive Proofs, Counterexamples, and Vacuous Proofs, Counting
- **Basic Structures (8 hours):** Set Theory – Cartesian Product & Binary Relation Partition, Function, Countable & Uncountable Sets
- **Introduction to Abstract Algebra (13 hours):** Group Theory, Rings and Fields, Vector Spaces, Finite Fields

- **Introduction to Number Theory (9 hours):** Divisibility and Modular Arithmetic, Integer Representations and Algorithms, Primes and Greatest Common Divisors, Solving Congruences
- **Introduction to Graph Theory (8 hours):** Graphs and Graph Models, Graph Terminology and Special Types of Graphs, Representing Graphs and Graph Isomorphism, Connectivity, Euler and Hamiltonian Graphs, Shortest-Path Problems, Planar Graphs, Graph Coloring

Learning Outcomes Expected:

After completing the course, the student will be able to:

- use logical notation to define and reason mathematically about the fundamental data types and structures (such as numbers, sets) applied in computer algorithms and systems
- identify and apply properties of combinatorial structures and properties
- visualize the different abstract structures (like Group, Rings and Fields)
- apply the concept of abstract algebra and number theory for the development of various cryptographic primitives
- understand the various types of graph Algorithms and graph theory properties along with model real world problems using graph theory

Contact Details: Dr. Dhananjoy Dey, Department of Mathematics, IIITL, ddey@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Kenneth H. Rosen, *Discrete Mathematics and Its Applications*, Eighth Edition, McGraw-Hill Education, 2019.
2. John B. Fraleigh, *A First Course in Abstract Algebra*, Seventh Edition, Pearson Education India, 2013.

- **References**

1. Owen D. Byer, Deirdre L. Smeltzer, & Kenneth L. Wantz, *Journey into Discrete Mathematics*, AMS/MAA Textbooks, Volume 41, 2018.
2. David M. Burton, *Elementary Number Theory*, Seventh Edition, The McGraw-Hill Companies, 2011.
3. F. Harary, *Graph Theory*, Narosa Publishing House, 2001.
4. I. N. Herstein, *Topics in Algebra*, Second Edition, John Wiley & Sons, 1975.
5. Harry Lewis, & Rachel Zax, *Essential Discrete Mathematics for Computer Science*, Princeton University Press, 2019.
6. Gerard O'Regan, *Guide to Discrete Mathematics: An Accessible Introduction to the History, Theory, Logic and Applications*, Springer 2016.

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Department of Computer Science

Semester: IV

Course Code: OSY4301C

Course Name: Operating System

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

Covers the classical internal algorithms and structures of operating systems, including CPU scheduling, memory management, and device management. Considers the unifying concept of the operating system as a collection of cooperating sequential processes. Covers topics including file systems, virtual memory, disk request scheduling, concurrent processes, deadlocks, security, and integrity. The main objectives of the course are outlined as follows:

- To understand the services provided by and the design of an operating system.
- To understand the structure and organization of the file system.
- To understand what a process is and how processes are synchronized and scheduled.
- To understand different approaches to memory management.
- Students should be able to use system calls for managing processes, memory and the file system.
- Students should understand the data structures and algorithms used to implement an OS.

Pre-Requisites: Fundamental of Electronics Engineering, Data Structure, Data Communications.

Description

- **Introduction of Operating System (3 hours):** Review of computer organization, Introduction to popular operating systems like UNIX, Windows, etc., OS structure, System calls, Functions of OS, evolution of OSs.
- **Computer organization interface (2 hours):** Using interrupt handler to pass control between a running program and OS.
- **Concept of a process (3 hours):** States, Operations with examples from UNIX (fork, exec) and/or Windows. Process scheduling, Interprocess communication (shared memory and message passing).
- **Threads (3 hours):** Multithreaded model, Scheduler activations, Examples of threaded programs.
- **Process Scheduling (6 hours):** Multi-programming and time sharing, Scheduling algorithms, multiprocessor scheduling, Thread scheduling (examples using POSIX threads).
- **Process synchronization (6 hours):** Critical sections, Classical two process and n-process solutions, Hardware primitives for synchronization, Semaphores, Monitors, Classical problems in synchronization (producer-consumer, readers-writer, dining philosophers, etc.).
- **Deadlocks (5 hours):** Modeling, Characterization, Prevention and avoidance, Detection and recovery.
- **Memory Management (6 hours):** With and without swapping, Paging and segmentation, Demand paging, Virtual memory, Page replacement algorithms, Working set model, Implementations from operating systems such as UNIX, Windows. Current Hardware support for paging: e.g., Pentium/ MIPS processor etc.
- **Secondary storage and Input/Output (4 hours):** Device controllers and device drivers, Disks, scheduling algorithms, File systems, Directory structure, Device controllers and device drivers, Disks, Disk space management, Disk scheduling, NFS, RAID, other devices.
- **Protection and security (2 hours):** Illustrations of security model of UNIX and other OSs. Examples of attacks.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand the structure and functions of Operating System.
- Learn about Processes, Threads and Scheduling algorithms.
- Learn about Processes, Threads and Scheduling algorithms.
- Learn various memory management schemes.
- Study I/O management and File systems.
- Understand the high-level structure of the Linux kernel both in concept and source code.

- Acquire a detailed understanding of one aspect (the scheduler) of the Linux kernel.
- Learn the basics of Linux system and perform administrative tasks on Linux Servers.

Contact Details: Dr. Mainak Adhikari, Department of Computer Science, IIITL, mainak@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Abraham Silberschatz, Peter B. Galvin and Greg Gagne, *Operating Systems Concepts*, Wiley, 2012.
  2. Maurice Bach, *The Design of the Unix Operating System*, Prentice Hall, 1988.
  3. William Stallings, *Operating Systems: Internals and Design Principles*, Prentice-Hall, 6th Ed., 2008.

- **References**

  1. Andrew S Tanenbaum and Herbert Bos, *Modern Operating Systems*, Fourth Edition, Pearson Education, 2014.
  2. Thomas Anderson and Michael Dahlin, *Operating Systems: Principles and Practice*, Recursive Books, 2014.

FIFTH SEMESTER

Indian Institute of Information Technology, Lucknow

भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Mathematics

Semester: V

Course Code: FCR5300C

Course Name: Foundations of Cryptography

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT and CS)

Course Module Details

Objective(s)

Cryptography has a long and important history in protecting critical systems and sensitive information. This is one of the most important component of our secure online communication. This course introduces students to the theoretical foundations of modern cryptography. The course will mainly focus on general principles related to encryption (private key as well as public key), key-less cryptographic primitives, digital signature, message authentication and key establishment.

Pre-Requisites: Knowledge of Modern & Linear algebra, Elementary Number Theory, Probability & Statistics and Computer Programming would be of great help.

Description

- **Introduction to Cryptography (2 hours):** Cryptosystems and Basic Cryptographic Tools, Message Integrity, Cryptographic Protocols, Security
- **Classical Cryptography (4 hours):** Introduction to some Simple Cryptosystems (Pen & Paper Ciphers), Cryptanalysis
- **Shannon's Theory, Perfect Secrecy, and the One-Time Pad (4 hours)**
- **Block Ciphers (8 hours):** Substitution-Permutation Networks (SPN), Security of Block Ciphers, The Data Encryption Standard (DES), The Advanced Encryption Standard (AES), Modes of Operation

- **Stream Ciphers (6 hours):** Linear Feedback Shift Registers, Non-linear Combinations of LFSRs, RC4 and Related Ciphers
- **Hash Functions and Message Authentication (6 hours):** Hash Functions and Data Integrity, Security of Hash Functions, Iterated Hash Functions (MD-SHA family), The Sponge Construction (SHA-3), Message Authentication Codes, Unconditionally Secure MACs
- **Public Key Cryptography (8 hours):** RSA, ElGamal and Elliptic Curves Cryptosystems and their security
- **Signature Schemes (1 hours):** RSA Signature Scheme, The ElGamal Signature Scheme, Variants of the ElGamal Signature Scheme, Security of these schemes
- **Key Establishment Protocols (3 hours):** Attack Models and Adversarial Goals, Key Predistribution, Session Key Distribution Schemes, Re-keying and the Logical Key Hierarchy, Threshold Schemes

Learning Outcomes Expected:

After completing the course, the student will be able to:

- explain the fundamentals of cryptography, such as encryption, digital signatures and secure hashes
- choose appropriate techniques and apply them to solve a real world problem for secure communication
- design and analyse security protocols appropriate for a given situation
- demonstrate an understanding of some legal and socio-ethical issues surrounding cryptography

Contact Details: Dr. Dhananjoy Dey, Department of Mathematics, IIITL, ddey@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. D. R. Stinson & M. B. Paterson, *Cryptography – Theory and Practice*, CRC, 2019.
2. J. Katz & Y. Lindell, *Introduction to Modern Cryptography*, CRC Press, 2015.

- **References**

1. Chuck Easttom, *Modern Cryptography: Applied Mathematics for Encryption and Information Security*, McGraw-Hill Education, 2016.
2. Neal Koblitz, *A Course in Number Theory and Cryptography*, Springer- Verlag, 1994.
3. Keith Martin, *Cryptography: The Key to Digital Security, How It Works, and Why It Matters*, W. W. Norton & Company, 2020.
4. Nigel P. Smart, *Cryptography Made Simple*, Springer, 2016.
5. William Stallings, *Cryptography and Network Security: Principles and Practice*, Pearson Education Canada, 2020.

Department of Mathematics

Semester:V

Course Code: MCS5300C

Course Name: Mathematics for Computer Science II

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (CS,CS-AI)

Course Module Details

Objective(s)

To provide the students the necessary mathematical background for Machine Learning and related areas.

Pre-Requisites: Nil.

Description

- **Linear Algebra(7 hours):** Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings.
- **Analytic Geometry(7 hours):** Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations.
- **Matrix Decompositions(7 hours):** Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.
  ‘
- **Vector Algebra(2 hours):** Vectors in $\mathbb{R}^3$, dot product of vectors, length of a vector, orthogonality of vectors, cross product of vectors.
- **Geometry in $\mathbb{R}^3$(3 hours):** Lines, Planes and quadric surfaces.
- **Vector valued functions:(3 hours)** Continuity and differentiability of vector valued functions of real variable, curves in $\mathbb{R}^3$, tangent vectors.

- **Multivariable functions:(6 hours)** Limits and continuity, partial derivatives, gradient, directional derivatives, maxima, minima, saddle points, Lagrange multipliers.
- **Integration:(7 hours)** Double and triple integrals, change of co-ordinates, vector fields, line integrals, surface integrals, statements of Green's, Divergence, and Stokes theorems, and their applications.

Learning Outcomes Expected:

- Solving systems of equations
- Able to find bases for the four fundamental subspaces
- Understanding projections, Orthogonalization by Gram-Schmidt process
- Using and understanding properties of determinants, their applications.
- Computing Eigenvalues and eigenvectors, diagonalizing matrices.
- Knowing symmetric matrices, linear transformations, decomposing matrices.
- Visualising functions of 2 and 3 variables using level curves and level surfaces.
- Computing partial derivatives, directional derivatives, and gradients.
- Optimizing multivariable functions subject to constraint equations.
- Representing the linear approximation of a multivariable function using vectors and matrices.

Contact Details:

- Dr. Mary Samuel, Department of Mathematics, IIITL, marysamuel@iiitl.ac.in
- Dr. Indira Mishra, Department of Mathematics, IIITL, indira@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Gilbert Strang, *Introduction to Linear Algebra*, fifth edition Wellesley-Cambridge Press, 2016.
2. Gilbert Strang, *Linear Algebra and Learning from Data*, Wellesley-Cambridge Press, 2019.
3. J. Hass, C. Heil, M, D. Weir, G. B. Thomas, *Thomas Calculus*, Pearson Education; Fourteenth Edition, 2018.
4. G. Strang, *Calculus*, Wellesley-Cambridge Press, Second edition, 2010.

- **Reference Books**

1. E. Kreyszig, *Advanced Engineering Mathematics*, Tenth Edition, John Willey and Sons, 2011.
2. T. M Apostol, *Mathematical Analysis*, Second Edition, Narosa Publisher, 2002.

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Department of IT

Semester: V

Course Code: SCO5301C

Course Name: Soft Computing

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT)

Course Module Details

Objective(s)

The course discusses soft computing techniques and their real-world applications. Course consists of fuzzy logic, its representation implementation. Detailed discussion on single and multiple objective optimization problem solving techniques are included in this course. This course also explains evolutionary algorithm and their adaptive nature to solve different optimization problems. Ant Colony Optimization, Particle Swarm Optimization, and Genetic Algorithm structure, role, and application will be covered in this course. ANN model, training and implementation with current state of the art will be covered in this course.

Pre-Requisites: Basic knowledge of MATLAB and discrete mathematics to understand the concepts of fuzzy logic.

Description

- **Module 1 (Contact hours: 15)** Introduction to soft computing: Soft Computing definition, soft computing Vs hard computing, Applications of soft computing Techniques, Introduction and Fuzzy Logic: Fuzzy set, Operation on Fuzzy set, fuzzy membership function, fuzzy proposition, fuzzy interference, Fuzzy relations, application of fuzzy logic, removal of fuzziness.
- **Module 2 (Contact hours: 15)** ANN and hybrid system: Introduction to Artificial Neural Network, MP Neuron Model, Perceptron Model, Sigmoid Neuron Model, Weight settings, activation function, back-propagation, Gradient Descent Optimization for ANN Training and applications of ANN.

- **Module 3 (Contact hours: 10)** Evolutionary Algorithms: Genetic Algorithm, Schema Theory, GA Operators: Encoding, Crossover, Mutation, Selection, etc., Particle Swarm Optimization, Artificial Bee Colony.

Laboratory Experiments:

Fuzzy Logic, Multi Objective Optimization, ANN Implementation on MATLAB/Pyhton

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Design fuzzy logic controller.
- Solve single or multi-objective optimization problems.
- Apply soft computing techniques to many real-world applications.

Contact Details: Dr. Rahul Kumar Verma, Department of Computer Science, IIITL, rahul@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. S. Rajasekaran and G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, PHI Learnings Pvt. Ltd.
  2. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley.

- **References**

  1. Fakhreddine O. Karray and Clarence De Silva, *Soft Computing and Intelligent Systems Design - Theory, Tools and Applications*, Pearson.

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Department of M&H

Semester: V

Course Code: PMA5300C

Course Name: People Management

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The main objective of the people management course is to impart the essence of people management concepts for the purpose of applying such knowledge into the practice. The course emphasizes on creating effective managers and team members; able to lead and manage self and others in the organizations and achieve goals business effectively.

Pre-Requisites: No prior experience is assumed. However, basic knowledge about behavior, workplace and business are assumed.

Description

- **Understanding people management (9 hours):** What is people management? How people management differs from human resource management, Effective people manager: roles and skills, understanding human behavior in organizational context, Different factors influencing employee behavior
- **Getting work done through others (12 hours):** Understanding employee personality, their attitude and motivation factors, Designing and assigning tasks and jobs effectively, Reinforcement, Handling Power, politics and conflict, Creating an ethical and positive organizational culture
- **Assessment, evaluation and feedback (7 hours):** Evaluating and enhancing employee performance, Goal settings, coaching, Performance evaluation

- **Managerial effectiveness: Managing self and teams (14 hours):** Emotional intelligence: understanding self and others, Strategies for emotion regulation, Measures for rectification perceptual and attribution errors, turning individuals into team players, building creative team, managing global team, Increasing employee productivity and work satisfaction, Mmanaging organizational change and workforce diversity

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand the basic concepts and models of people management and their applications to develop employee's effectiveness in organization.
- Acquire knowledge about personality, attitude, motivation and learning and the efficient applications of these concepts at workplace and real life.
- Comprehend the essentials of building and managing teams to know how to form groups & teams at work in an organization and actualize team effectiveness.
- Understand and use emotional intelligence at work place efficiently.

Contact Details: Dr. Bindu Singh, Department of Management & Humanities, IIITL, bindu.singh@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Stephen P. Robbins, Timothy A. Judge & Neharika Vohra *Organizational Behavior*, 18th Edition Pearson Education, 2017
2. Gary Dessler, *Human Resource Management*, 15th Edition, Pearson Education, 2019.

- **References**

1. Bohlander and Snell, *Principles of Human Resource Management*, 16th Edition, Cengage Learning, 1988.
2. K. Aswathappa, *2. Human Resource Management, Text and Cases*, 8th Edition, Tata Mc-Graw Hill education, 2017.

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Department of Management & Humanities

Semester: V

Course Code: BDM5300C

Course Name: Business Decision Making

Credits	L	T	P	Section (Group)
3	3	0	0	B.Tech. (CSB)

Course Module Details

Objective(s)

The objectives of the business decision-making course are to:

- Analyze the business problems/ issues/ opportunities and formulate research problems in the given context to improve decision-making.
- Develop appropriate research design according to the needs and criteria of the business problems.
- Understand the measurement methods, sampling techniques, sample size determination procedures, and data collection methods, and identify the appropriate research methods.
- Analyze data using technology tools like SPSS and AMOS, interpret the results and prepare research reports to solve business problems/ issues/ opportunities in various domains.

Pre-Requisites: NIL.

Description

- **Unit 1: Introduction to business decision making (6 hours):** Introduction to business decision making, The role of business research, business research process. Ethical and organizational issues in business research. Formulate the business decision making problem, Formulate the research question, Develop a research approach

- **Unit 2: Research design (10 hours):** Introduction to research design, Need, criteria and types of research design, Exploratory research design: secondary and syndicated data, Secondary research in the digital age, Exploratory research design: qualitative research, Descriptive research design, Causal and longitudinal research design, Experimentation
- **Unit 3: Measurement methods, sampling (6 hours):** Measurement and scaling concepts, Criteria for good measurement, Attitude measurement, Sampling design and procedures, Statistics of sampling: sample size determination, Statistical theory, and standards.
- **Unit4: Data collection (5 hours):** primary sources and secondary sources, Primary methods of data collection- observation and interview, Primary methods of data collection-schedule, questionnaire, case study, and survey methods. Qualitative techniques of data collection: observation and content analysis focus group method, personal interview and projective techniques, Quantitative techniques of data collection: Surveys: (paper, kiosk, mobile, questionnaires), Questionnaire design: use of technology
- **Unit 5: Data preparation, analysis, and reporting (15 hours):** Data preparation: transforming raw data into information, Descriptive statistics, Analysis of variance and covariance. Hypothesis testing, Correlation and regression, Factor analysis, Cluster analysis, Multidimensional scaling, Structural equation modeling, and path analysis, SPSS and AMOS to analyze data, Report preparation: guidelines for report writing, components of report writing

Learning Outcomes Expected:

Numerous outcomes will be achieved upon completion of the course:

- Students will get an understanding of the numerous processes that are involved in business decision-making.
- Students will learn about the various types of research designs that can be used to make an effective decision.
- In addition, students will learn how to recognize the numerous types of variables and constructs that are used in effective decision-making.
- Students will learn how to choose the proper sample size and sampling technique to make an effective decision.
- Students will also gain an understanding of the various types of data analytics techniques, as well as the development and testing of hypotheses.

Contact Details: Dr. Niraj Kumar Vishvakarma, Department of Management & Humanities, IIIL, niraj@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Donald and Cooper , *Business Research Methods*, 12th Edition, McGraw-Hill, 2018.
2. William G. Zikmund, Dr Christina Quinlan, Mitch Griffin, Barry Babin, Jon Carr, *Business Research Methods*, 2nd Edition, Cengage Learning, 2019.

- **References**

1. Naresh K. Malhotra and Satyabhusan Das, *TMarketing Research : An Applied Orientation* , 7th Edition, Pearson India, 2019.
2. Bell, E., Bryman, A., & Harley, B, *Business Research Methods*, 5th Edition, Oxford university press, 2018.

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Department of Management and Humanities

Semester: V

Course Code: BEC5400C

Course Name: Business Economics

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech. (CSB)

Course Module Details

Objective(s)

Economics deals with problems and questions that affect almost all kinds of individuals in their capacities as consumers and producers. Therefore, economic literacy is very essential for everyone. Business Economics which integrates economic theory with business practice will help in the process of business decision making.

Pre-Requisites: Nil

Description

- **Introduction to Business Economics (4 hours):** Meaning and scope of Business Economics,Basic Problems of an Economy, PPC,Opportunity Cost
- **Theory of Demand and Supply (14 hours):** Meaning and Determinants of Demand, Law of Demand, why demand curve slopes downward, exceptions to law of demand and Elasticity of Demand–Price, Income and Cross Elasticity. Theory of Consumer's Behaviour– Marshallian approach and Indifference Curve approach.Meaning and Determinants of Supply, Law of Supply and Elasticity of Supply.
- **Theory of Production (8 hours):** Meaning and Factors of Production. Concept of TP, AP, MP. Laws of Production of Variable Proportions and Laws of Returns to Scale
- **Theory of Cost and Revenue (10 hours):** Concepts of Costs – Short-run and long-run costs, Average and Marginal Costs, Total, Fixed and Variable Costs.Concepts of Revenue- TR, AR and MR and their relations.Producer's Equilibrium

- **Forms of Market and Price Determination (12 hours):** Various forms of Markets – Perfect Competition, Monopoly, Monopolistic Competition and Oligopoly.Price- Output Determination under different Market Forms.
- **Presentations / Group discussions: On current topics. (8 hours)**

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Develop an understanding of the concepts and theories in Business Economics
- Understand the economic environment and its impact.
- Apply such concepts and theories in simple problem solving.
- Apply economic theories in the process of business decision making.

Contact Details: Dr. Varun Sharma, Department of Management and Humanities, IIIL, varun@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Robert E. Hall, Marc Lieberman , *Microeconomics: Principles and Applications*, Cengage Learning, 2009.
2. Pindyck, Robert S. & Rubinfeld Daniel , *Microeconomics*, Pearson Education, 2013.

- **References**

1. Edgar K. Browning, Mark A. Zupan, *Microeconomics: Theory and Applications*, John Wiley & Sons, 2020.
2. Mankiw, Gregory N , *Principles of Economics*, South-Western Publishing Co.,2012

SIXTH SEMESTER

Indian Institute of Information Technology, Lucknow

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Department of Management and Humanities

Semester: VI

Course Code: TEN6400C

Course Name: Techno-Entrepreneurship

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The main objective of the Techno-entrepreneurship course is to impart the essence of entrepreneurship and tech enabled entrepreneurship for the purpose of applying such knowledge into the practice. The course emphasizes on creating entrepreneur who can successfully start and lead their venture and turn into successful businessman/businesswomen. This course also aims to create effective managers having entrepreneurial skills to achieve goals of business effectively.

Pre-Requisites: No prior experience is assumed. However, basic knowledge about behaviour, workplace and business are assumed.

Description

- **Evolution of Entrepreneur (4 hours):** Concept, Entrepreneur Vs. Entrepreneurship, Entrepreneur Vs. Intrapreneur, Entrepreneur Vs. Manager, Characteristics of a successful Entrepreneur, Digital businesses, Tech enabled entrepreneurship, how technology is shaping entrepreneurship in current scenario, future of tech enabled businesses.
- **Role of Entrepreneur in developing economies (6 hours):** Entrepreneurial Culture, Creating Entrepreneurial Venture
- **Theory of Production (8 hours):** Meaning and Factors of Production. Concept of TP, AP, MP. Laws of Production of Variable Proportions and Laws of Returns to Scale

- **Environmental Analysis (4 hours):** Search and Scanning, Identifying problems and opportunities, Government Procedures
- **Estimating and Financing funds requirement (14 hours):** Schemes offered by various commercial banks and financial institutions like IDBI, ICICI, SIDBI, SFCs, Venture Capital Funding .
- **Entrepreneurship Development: (12 hours):** Role of Central Government and State Government in Entrepreneurship, Introduction to various incentives, subsidies and grants
- **Role of agencies in the Entrepreneurship Development (12 hours):** Small Industries Service Institute (SISI), National Institute of Entrepreneurship & Small Business Development (NIESBUD), District Industries Centers (DIC), National Entrepreneurship Development Board (NEDB), Entrepreneurship Development Institute of India (EDII)
- **Why do Entrepreneurs fail (2 hours):** The FOUR Entrepreneurial Pitfalls?
- **Women Entrepreneurs (2 hours):** Problems and Prospects, Case studies of Successful and Failed Entrepreneurial Ventures Role

Learning Outcomes Expected:

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

- Learn how to identify, examine and evaluate business opportunities and create new business ventures;
- Acquire knowledge how to develop effective business plans and how to reach financial institutions for capital
- Acquire knowledge about various sources of capital and understand legal issues in entrepreneurship
- Understand dos and don'ts of successful venture.

Contact Details: Dr. Bindu Singh, Department of Management & Humanities, IIITL, bindu.singh@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. Robert Hisrich, Michael Peters and Dean Shepherd, *Entrepreneurship*, 10th Edition, McGrawHill, 2017 .
- **References**
  1. 1. Vasant Desai, *Dynamics of Entrepreneurship Development*, Himalayan Publishing House, 2011
  2. 2. K. Nagarajan , *Project Management*, New Age International Publications, 2012

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Department of Computer Science

Semester: VI/ Elective

Course Code: DLE6301C

Course Name: Deep Learning

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (CS-AI, & Elective)

Course Module Details

Objective(s)

The objective of this course is to grow the knowledge on recent trends of advanced machine learning techniques.

Pre-Requisites: Machine Learning, Some basic knowledge of Linear Algebra and Calculus.

Description

- **Deep Neural Network (11 hours):**

  Introduction to Deep Learning: A brief overview of supervised, unsupervised, reinforcement learning, Difference between classification, regression, Traditional classifiers,

  Multilayer Perceptron: Feed-Forward Neural Network with Backpropagation,

  Different activation functions their advantages and disadvantages: Sigmoid (vanishing gradient problem), ReLU (exploding gradient problem), Leaky ReLU, tanh, etc.,

  Various loss and cost functions: MSE, log-loss, cross-entropy, hinge loss, etc.,

  Bias vs Variance trade-off,

  Regularization: L2 regularization, early stopping, data augmentation, Ensembling, Dropout, etc.,

  Optimization: Gradient Descent (GD), Batch GD, Stochastic GD, Minibatch GD, GD with momentum, Adagrad, RMSprop, Adam, etc.

- **Convolutional Neural Network (7 hours):**

  Introduction to Convolution Neural Network (CNN), Different operations of CNN (convolution, pooling), Different concepts of CNN (Kernel, Filter, Padding, Stride),

  Different CNN architecture (LeNet, AlexNet, VGG Net, GoogLeNet, SqueezeNet, Xception net, Residual block and ResNet, Dense Net, etc.),

  Transfer Learning, Similarity learning, Siamese Net, Triplet Net

- **Recurrent Neural Network (7 hours):**

  Introduction to sequential learning (Recurrent Neural Network: RNN), Backpropagation through time,

  Different RNN architectures: Gated Recurrent Unit (GRU), LSTM, Bi-directional LSTM, Deep RNN

- **Advanced Topics on Deep Learning (7 hours):**

  Autoencoder: Denoising autoencoder, Sparse autoencoder, Variational autoencoders, etc.,

  Generative Adversarial Network (GAN) and some of its variants, e.g., DCGAN, CycleGAN

- **Applications of Deep Learning (8 hours):**

  Application of Deep Learning (DL) in Computer Vision: Object Segmentation: U-Net, V-Net, Object Detection: RCNN, YOLO, etc.,

  Application of DL in Natural Language Processing (NLP): e.g., Sentiment Analysis from reviews

Learning Outcomes Expected:

After completing the course, the student will be able to

- Tackle real-life computation problems that can be addressed through deep learning,
- Understand various concepts of deep learning,
- Solve various computer vision and natural language processing problems,
- Demonstrate an understanding of some ethical issues related to artificial intelligence.

Contact Details: Dr. Chandranath Adak, Department of Computer Science, IIITL, chandra@iiitl.ac.in

Courseware and Reference Books

- **References**

1. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, MIT Press, 2016.
   Online: https://www.deeplearningbook.org.
2. A. Zhang, Z. C. Lipton, M. Li, A. J. Smola, *Dive into Deep Learning*, arXiv:2106.11342, 2021.
   Online: https://d2l.ai.

SEVENTH SEMESTER

Indian Institute of Information Technology, Lucknow

भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Computer Science

Semester: VII/ Elective

Course Code: NLP7301E

Course Name: Natural Language Processing

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (CS-AI, & Elective), M.Tech.

Course Module Details

Objective(s)

The general approach in the course will be covering (i) a language phenomenon, (ii) the corresponding language processing task, and (iii) techniques based on deep learning, classical machine learning and knowledge base(s). On one hand we will understand the language processing task in detail using linguistics, cognitive science, utility *etc.*, on the other hand we will delve deep into techniques for solving the problem. In addition to the graded labs, non-graded labs, and course project (graded), this course entails a *mid-semester* and an *end-semester* examination.

Pre-Requisites: Machine Learning, Linear Algebra, Calculus, and basics of Python programming.

Description

- **Week 01** (3 hours) - Introduction to Natural Language Processing (NLP)
  Course Introduction & Motivation, Multilingualism, Morphology in Languages, and
  Part-of-Speech (Pos) Tagging [Introduction].
- **Week 02** (3 hours) - PoS Tagging Layer of NLP
  Mathematics of PoS tagging, Sequences in NLP, and
  NLP Lab 1 (Non-graded) - Simple Matrix Operations, NumPy, scikit-learn
- **Week 03** (3 hours) - Hidden Markov Models (HMM) in NLP
  PoS Tagging (HMM), Viterbi Decoding for Tagging and Sequences, and
  NLP Lab 2 (Non-graded) - Most Frequent POS Tagging assignment.

- **Week 04** (3 hours) - Handling Sequential Tasks
  Shallow parsing, Named Entity Recognition (NER), Introduction to Conditional Random Field (CRF), and
  Challenges due to Morphological Richness.

- **Week 05** (3 hours) - Feature Engineering
  CRF (contd.), Maximum Entropy Markov Model (MEMM),
  Feature Extraction and Engineering, and
  NLP Lab 3 (Non-graded) - NER Task for multiple languages.

- **Week 06** (3 hours) - Knowledge Bases and Ambiguity
  Ambiguity and NLP, Knowledge Bases (WordNet, FrameNet, VerbNet *etc.*),
  Word Sense Disambiguation (WSD), and
  NLP Lab 4 (Graded) - Sense Disambiguation Task

- **Week 07** (3 hours) - Applications of Neural Networks (NN) in NLP
  Cognate Detection and its applications,
  NER using NNs, Text Classification using NNs
  Transformer Architecture, and Introduction to Distributional Semantics.

- **Week 08** (3 hours) - Distributional Semantics
  word2vec, doc2vec, sent2vec, sub-words in NLP, and FastText
  NLP Lab 5 (Non-graded) - word2vec, GloVe and FastText (pre-trained models),
  Embeddings Space Visualization.

- **Week 09** (3 hours) - Language Models (LMs)
  Introduction to State-of-the-Art LMs, BERTology, BERT-based fine-tuning for various NLP tasks, and
  NLP Lab 6 (Graded Lab) - NER Task with LMs.

- **Week 10** (3 hours) - Machine Translation (MT)
  Introduction to Machine Translation (MT),
  Statistical MT (SMT), Neural MT (NMT),
  NLP Lab 7 (NG) - SMT, Moses, Alignment Task.

- **Week 11** (3 hours) - Sentiment Analysis (SA)
  Introduction to Sentiment Analysis (SA), Aspect Based SA, Sarcasm Detection, Thwarting, and Introduction to Course Project.

- **Week 12** (3 hours) - Information Extraction (IE)
  Question Answering, Summarization, Essay Grading, and
  NLP Lab 8 (Graded) - Aspect-based SA.

- **Week 13** (3 hours) - Cognitive NLP
  Cognitive Behaviour, Introduction to Eye-tracking (ET) / EEG,
  Ethics and Bias in NLP, Features from ET, NLP Tasks with ET.

- **Week 14** (1 hour) - Course Project
  One hour for discussion on project progress,
  Other two hours for evaluation of the project.

Learning Outcomes Expected:

At the end of this course, all the attending students are expected to be able to:

- Demonstrate an understanding for various NLP sub-problems,
- Design solutions for real-world NLP challenges,
- Solve NLP problems/challenges with the help of Machine Learning- and Deep Learning-based approaches,
- Demonstrate an understanding of ethical issues, and bias in Artificial Intelligence (AI)-based problems.

Contact Details:

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Dr Rudra Murthy V, Department of CS, IIITL, rudramurthy@iiitl.ac.in

Courseware and Reference Books

Note: This is not an exhaustive list of reading proposed by the course instructors. We shall add to this list as the course progresses.

- Allen, James, *Natural Language Understanding*, Second Edition, Benjamin/Cumming, 1995. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993
- Jurafsky, Dan and Martin, James, *Speech and Language Processing*, Speech and Language Processing (3rd ed. draft), Draft chapters in progress, October 16, 2019.
- Manning, Christopher and Heinrich, Schutze, *Foundations of Statistical Natural Language Processing*, MIT Press, 1999.
- Jacob Eisenstein, *Introduction to Natural Language Processing*, MIT Press, 2019.
- Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.
- Radford, Andrew et. al., Linguistics, an Introduction, Cambridge University Press, 1999.
- Pushpak Bhattacharyya, Machine Translation, CRC Press, 2017.
- **Journals**: Computational Linguistics, Natural Language Engineering, Machine Learning, Machine Translation, Artificial Intelligence
- **Conferences**: Annual Meeting of the Association of Computational Linguistics (ACL), Computational Linguistics (COLING), European ACL (EACL), Empirical Methods in NLP (EMNLP), Annual Meeting of the Special Interest Group in Information Retrieval (SIGIR), Human Language Technology (HLT).
- Sag, Ivan A., Timothy Baldwin, Francis Bond, Ann Copestake, and Dan Flickinger. "Multiword expressions: A pain in the neck for NLP." In International conference on intelligent text processing and computational linguistics, pp. 1-15. Springer, Berlin, Heidelberg, 2002.

- Mitchell P. Marcus, Mary Ann Marcinkiewicz, and Beatrice Santorini. 1993. Building a Large Annotated Corpus of English: The Penn Treebank. Comput. Linguist., 19(2):313–330, June.
- Xuezhe Ma and Eduard H. Hovy. 2016. End-to-end Sequence Labeling via Bi-directional LSTM-CNNs-CRF. CoRR, abs/1603.01354. (comment: POS and NER)
- Anders Søgaard and Yoav Goldberg. 2016. Deep multi-task learning with low level tasks supervised at lower layers. In Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers), pages 231–235, Berlin, Germany, August. Association for Computational Linguistics.
- Chapter 2 of Machine Translation by Professor Pushpak Bhattacharyya.
- Smoothing from Manning and Schutz, "Foundations of Statistical Natural Language Processing", Page 199 (general) and Page 354 (POS specific).
- Sha, Fei, and Fernando Pereira. "Shallow parsing with conditional random fields." In Proceedings of the 2003 Human Language Technology Conference of the North American Chapter of the Association for Computational Linguistics, pp. 213-220. 2003.
- Ratnaparkhi, Adwait. "A maximum entropy model for part-of-speech tagging." In Conference on empirical methods in natural language processing. 1996.
- Harshada Gune, Mugdha Bapat, Mitesh Khapra and Pushpak Bhattacharyya, Verbs are where all the Action Lies: Experiences of Shallow Parsing of a Morphologically Rich Language, Computational Linguistics Conference (COLING 2010), Beijing, China, August 2010.
- Erik F. Tjong Kim Sang and Sabine Buchholz, Introduction to the CoNLL-2000 Shared Task: Chunking. In: Proceedings of CoNLL-2000, Lisbon, Portugal, 2000.
- John Lafferty, Andrew McCallum, and Fernando C.N. Pereira, "Conditional Random Fields: Probabilistic Models for Segmenting and Labeling Sequence Data", ICML 2001.
- Toutanova, Kristina; Manning, Christopher D. (2000). "Enriching the Knowledge Sources Used in a Maximum Entropy Part-of-Speech Tagger". Proc. J. SIGDAT Conf. on Empirical Methods in NLP and Very Large Corpora (EMNLP/VLC-2000). pp. 63–70.

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Department of Management and Humanities

Semester: VII

Course Code: PET7200C

Course Name: Professional Ethics

Credits	L	T	P	Section (Group)
2	2	0	0	B.Tech(IT, CS, CS-AI, & CSB).

Course Module Details

Objective(s)

The main objective of the professional ethics course is to impart the essence of basics of ethical concepts for the purpose of applying such knowledge into the practice. .

Pre-Requisites: No prior experience is assumed. However, basic knowledge about ethics and value systems are assumed.

Description

- **Introduction to Professional Ethics (6 hours):** Distinguish between moral, ethics and ethical theory, The Development of Ethics, Ethical challenges in different types of organizations, Ethical Culture
- **Framing Professional Ethics (4 hours):** Stakeholder theory and perspective, Corporate Social Responsibility
- • **Evaluating Professional Ethics (4 hours):** Normative Ethical Theories, Descriptive Ethical Theories
- **Ethical leadership (2 hours):** Various Leadership style shaping decision making
- **Individual and Organizational factors influencing Professional Ethics (2 hours):** Cognitive Moral development, Role of Ethical Culture

- **Institutionalization of Professional Ethics (4 hours):** Emerging ethical issues in business
- **Case studies (6 hours):** of Failed Entrepreneurial Ventures due to ethical issues

Learning Outcomes Expected:

After completing this course, student will be able to:

- Understand the notion of professional ethics and ethical culture in changing business environment.
- Analyse the implications of stakeholder perspective and corporate social responsibility in different contexts; evaluate different ethical theories (Normative and Descriptive) and identify, analyse and resolve ethical issues in business decision making.
- Understand individual and organizational factors (Leadership style and Culture) influencing professional ethics and ethical decision making.

Contact Details: Dr. Bindu Singh, Department of Management & Humanities, IIITL, bindu.singh@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Andrew Crane and Dirk Matten , *Business Ethics, International Edition* , by Oxford Publications

- **Reference Books:**

  1. Ferrel, Fraedrick and Ferrel, *1. Business Ethics, Text and Cases* . 9th Edition,2018,Cengage Learning
  2. Boatright, Patra and Smith , *1. Business Ethics, Text and Cases 8th Edition* , Pearson Education.

EIGHTH SEMESTER

POOL OF ELECTIVES

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Department of Mathematics

Semester:VI

Course Code: AGT6310E

Course Name: Algorithmic Graph Theory

Credits	L	T	P	Section (Group)
4	3	1	0	B.Tech. (IT, CS)

Course Module Details

Objective(s)

To present graph theory as an useful analytical tool for computer scientists.

Pre-Requisites: Some exposure to a high level, procedural and preferably recursive programming language, to be familiar with elementary set notation and to be at ease with theorem proving.

Description

- **Introducing graphs and algorithmic complexity(5 hours):** Introducing graphs,Introducing algorithmic complexity,Introducing data structures and depth-first searching.
- **Spanning-trees, branchings and connectivity(6 hours):** Spanning-trees and branchings, Circuits, cut-sets and connectivity.
- **Planar graphs(6 hours):** Basic properties of planar graphs, Genus, crossing-number and thickness, Characterisations of planarity,A planarity testing algorithm.
- **Networks and flows(6 hours):** Networks and flows, Maximising the flow in a network,Menger's theorems and connectivity, A minimum-cost flow algorithm.
- **Matchings(5 hours):** Definitions, Maximum-cardinality matchings, Maximum-weight matchings.
- **Eulerian and Hamiltonian tours(5 hours):** Eulerian paths and circuits, Hamiltonian tours.
- **Colouring graphs(6 hours):** Dominating sets, independence and cliques, Colouring graphs, Face-colourings of embedded graphs.
- **Introduction to NP-completeness(1 hour)**

Learning Outcomes Expected:

- To understand the basic language of graph theory and of algorithmic complexity.
- To get an idea of how spanning-trees play an important role in connection with the circuit space and with the separability of a graph.
- To determine what graphs can be arranged on a plane surface.
- To be able to solve a variety of problems is to model them in terms of some flow along the edges of a digraph.
- To understand matchings and to search for certain matchings can be an important subtask for some larger problems.
- To characterise the graphs that contain either Eulerian or Hamiltonian tours.
- To partition or colour the vertices, edges or faces of a graph in a way dependent upon their various adjacencies.
- To differentiate between those algorithms whose execution times are bounded by a polynomial in the problem size and those which are not.

Contact Details: Dr. Mary Samuel, Department of Mathematics, IIITL, marysamuel@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Alan Gibbons, *Algorithmic Graph Theory*, Cambridge University Press, 1985.

- **References**

1. Cormen, Leiserson and Rivest, *Introduction to Algorithms*, McGraw-Hill, 1986.
2. James McHugh, *Algorithmic Graph Theory*, Prentice-Hall, 1989.
3. M. C. Golumbic , *Algorithmic Graph Theory and Perfect Graphs,* , Volume 57 in the series Annals of Discrete Mathematics. North Holland, second edition, 2004.

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Department of CS/IT

Semester: Elective

Course Code:

Course Name: AI for IoT

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective:

The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

Pre-Requisites: Basics of Programming Language (preferable Python), Cloud Computing, Comupter Network and Wireless Communication

Description

- **Introduction to IoT (10 Hours):** Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.
- **Elements of IoT (10 Hours):** Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.
- **IoT Applications (9 Hours):** Development Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.
- **AI based IoT Case studies (8 Hours):** IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

Learning Outcomes Expected:

After completing the course, the student will be able to

1. Understand internet of Things and its hardware and software components
2. Understand the design aspects of hardware and software components of IoT.
3. Design Interface for Input and Output devices, sensors communication modules.
4. Analyze and process of data from sensors
5. Apply IoT knowledge to Implement basic IoT applications on embedded platform.

Contact Details: Dr. Niharika Anand , Department of IT, IIITL, niharika@iiitl.ac.in

Courseware and Reference Books

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRCPress
2. Vijay Madisetti, Arshdeep Bahga, İnternet of Things, "A Hands on Approach", UniversityPress
3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internetof Things: A practical Approach", ETILabs
4. Adrian McEwen, "Designing the Internet of Things",Wiley

In addition to the above references, selection of papers from leading conferences and journals can also be referred for details.

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Department of CS/IT

Semester: Elective

Course Code: AIN6301E

Course Name: Artificial Intelligence

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s) To learn how human intelligence work. To learn the algorithms applied by human brain in solving problems.

Pre-Requisites Probability, Discrete Mathematics

Description

- **Introduction (8 Hours):** Searching, Planning and Uncertainty Introduction: Definition, Foundations, History, Current AI systems. Intelligent Agents: Agents and environment, Rationality, PEAS, Nature of Environment, Different types of agents. Searching: Agent design, Toy Problems, Searching, Tree Search and Graph
- **Uninformed Search (8 Hours):** Search, Uninformed Search, Breadth First Search, Depth First Search, Depth-Limited Search, Iterative Deepening, Iterative Lengthening, Bidirectional Search, Sensor less problems, Contingency problems.
- **Informed Search (8 Hours):** Informed Search: Informed/Heuristic Search, Heuristic Search, A* Search, Memory bounded heuristic search, heuristic functions, local search and optimization, hill-climbing, simulated annealing, local beam search, online search, online depth first search.
- **Constraint Satisfaction (10 Hours):** Constraint Satisfaction Problems, Backtracking, Minimum Remaining Values heuristic, Most Constraint Variable heuristic, Least Constraining Value heuristic, Forward Checking, Constraint Propagation, local search, problem decomposition.

- **Adversarial Search (10 Hours):** Games, optimal decisions in games, minimax algorithm, multi-player games, alpha-beta pruning, evaluation functions, cutting 0 search, expecti minimax algorithm, dice/card games.
- **Planning (5 Hours):** The planning problem, language specification and PDDL, examples of planning problems, forward search, backward search, heuristics.

Learning Outcomes Expected:

After completing the course, the student will be able to design search based logical agents. They will also be able to design classification frameworks.

Contact Details: Dr. Soumendu Chakraborty, Department of CS, IIITL, soumendu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. S. Russell and P. Norvig *Artificial Intelligence*, Fourth Edition, Pearson.

- **References**

  1. D. Khemani, *A first course in Artificial Intelligence*, Ninth Reprint McGraw Hill Education (India) Pvt. Ltd

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Department of Mathematics

Course Code: CAN7310E

Course Name: Computational Algebra and Number Theory

Credits	L	T	P	Section (Group)
4	3	1	0	B.Tech. (IT, CS, and CSAI)

Course Module Details

Objective(s)

Algebra and Number theory play an increasingly significant role in computing and communications. Applications of these subjects can be found in the fields of cryptography and coding theory. The concept of modern algebra is required for both finding algorithms, and understanding the limitations of computation. This course will mainly focus on the fundamentals of computing keeping algebra in the centre. It also covers the algebraic algorithms that have applications in real world. The objective of this course is to introduce both basic concepts and practical applications.

Pre-Requisites: Knowledge of Modern algebra, Elementary Number Theory, Theory of Computation, and Analysis of Algorithms

Description

- **Background (4 hours):** Algorithms and Their Complexity, Discrete Algebraic Structures, Arithmetic of Integers
- **Arithmetic of Finite Fields (4 hours):** Existence and Uniqueness of Finite Fields, Representation of Finite Fields, Some Properties of Finite Fields, Alternative Representations of Finite Fields
- **Arithmetic of Polynomials (9 hours):** Polynomials over Finite Fields, Finding Roots of Polynomials over Finite Fields, Factoring Polynomials over Finite Fields, Properties of Polynomials with Integer Coefficients, Factoring Polynomials with Integer Coefficients
- **Gröbner Bases (4 hours):** Gröbner bases, Applications of Gröbner bases

- **Primality Testing (5 hours):** Introduction to Primality Testing, Probabilistic Primality Testing, Deterministic Primality Testing, Primality Tests for Numbers of Special Forms
- **Integer Factorization (8 hours):** Trial Division, Pollard's Rho Method, Pollard's $p-1$ Method, Dixon's Method, Quadratic Sieve Method, Number-Field Sieve Method
- **Discrete Logarithms (8 hours):** Square-Root Methods, Algorithms for Prime Fields, Algorithms for Fields of Characteristic 2, Algorithms for General Extension Fields

Learning Outcomes Expected:

After completing the course, the student will be able to:

- compute Gröbner basis efficiently and also see its applications in solving system of multivariate equations
- efficiently implement algorithms for the most important problems from number theory
- visualize the major applications of computational algebra and number theory in cryptography as well as coding theory

Contact Details: Dr. Dhananjoy Dey, Department of Mathematics, IIITL, ddey@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. Abhijit Das, *Computational Number Theory*, CRC, 2013.
  2. Victor Shoup, *A Computational Introduction to Number Theory and Algebra*, Cambridge University Press, 2008.
     https://shoup.net/ntb/
- **References**
  1. Song Y. Yan, *Computational Number Theory and Modern Cryptography*, Wiley, 2013.
  2. Song Y. Yan, *Quantum Computational Number Theory*, Springer, 2015.

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Department of CS/IT

Semester: VI/Elective

Course Code: IVP6301E

Course Name: Image and Vision Processing

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s) To learn the Digital image representation, prepossessing of images (filtering in time and frequency domain), image feature extraction and analysis

Pre-Requisites Probability, Complex Numbers, Data Communication

Description

- **Introduction (8 Hours):** Elements of Visual Perception, Structure of the Human Eye, Image Formation in the Eye, Brightness Adaptation and Discrimination, Light and the Electromagnetic Spectrum, Image Sensing and Acquisition, Image Acquisition, Image Sampling and Quantization, Spatial and Intensity Resolution, Image Interpolation, Some Basic Relationships between Pixels, An Introduction to the Mathematical Tools Used in Digital Image, Linear versus Nonlinear Operations, Arithmetic Operations.
- **Image Transforms (6 Hours):** Probabilistic Methods, The Basics of Intensity Transformations and Spatial Filtering, Some Basic Intensity Transformation Functions, Image Negatives, Log Transformations, Power-Law (Gamma) Transformations, Piecewise-Linear Transformation Functions, Histogram Processing, Histogram Equalization, Histogram Matching (Specification), Local Histogram Processing, Using Histogram Statistics for Image Enhancement.
- **Spatial Filtering (6 Hours):** Fundamentals of Spatial Filtering, The Mechanics of Spatial Filtering, Spatial Correlation and Convolution, Vector Representation of Linear Filtering, Generating Spatial Filter Masks, Smoothing Spatial Filters, Smoothing Linear Filters, Order-Statistic (Nonlinear) Filters, Sharpening Spatial Filters, Second Derivative for Image Sharpening, The Laplacian, Unsharp Masking and High boost Filtering, Using First-Order Derivatives for (Nonlinear) Image, Sharpening.

- **Frequency Domain Filtering (12 Hours):** Complex Numbers, Fourier Series, Impulses and Their Sifting Property, The Fourier Transform of Functions of One Continuous, Convolution, Sampling and the Fourier Transform of Sampled Functions, The Sampling Theorem, Aliasing, Function Reconstruction (Recovery) from Sampled Data, The Discrete Fourier Transform (DFT) of One Variable, The 2-D Impulse and Its Sifting Property, 2-D Sampling Theorem, Aliasing in Images, Some Properties of the 2-D Discrete Fourier Transform, Fourier Spectrum and Phase Angle, The 2-D Convolution Theorem, Correspondence Between Filtering in the Spatial and Frequency, Ideal Lowpass Filters, Butterworth Lowpass Filters, Gaussian Lowpass Filters, Image Sharpening Using Frequency Domain Filters, Ideal Highpass Filters, Butterworth Highpass Filters, Gaussian Highpass Filters, The Laplacian in the Frequency Domain, Unsharp Masking, Highboost Filtering, and High-Frequency-Emphasis Filtering, Homomorphic Filtering, Selective Filtering, Bandreject and Bandpass Filters, Notch Filters.
- **Morphology (5 Hours):** Erosion and Dilation, Duality, Opening and Closing, The Hit-or-Miss Transformation, Some Basic Morphological Algorithms, Boundary Extraction, Hole Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons, Pruning
- **Image Segmentation (5 Hours):** Background Detection of Isolated Points, Line Detection, Edge Models, Basic Edge Detection, More Advanced Techniques for Edge Detection, Edge Linking and Boundary Detection, Thresholding, Foundation Basic Global Thresholding, Optimum Global Thresholding Using Otsu's Method, Using Image Smoothing to Improve Global Thresholding, Using Edges to Improve Global Thresholding, Multiple Thresholds, Variable Thresholding, Multivariable Thresholding.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand concepts required for image enhancement.
- Implement image preprocessing algorithms, Feature Extraction algorithms.
- Understand and implement spatial and frequency domain filtering for image enhancement.
- Concepts learnt in this course will help understand the advance concepts of computer vision.

Contact Details: Dr. Soumendu Chakraborty, Department of CS, IIITL, soumendu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. Rafael C. Gonzalez, and Richard E. Woods *Digital Image Processing*, Fourth Edition, Pearson.
- **References**
  1. Bernd Jähne, *Digital Image Processing*, Sixth Edition, Sringer

Department of Mathematics

Semester:VI

Course Code: NLA6310E

Course Name: Numerical Linear Algebra

Credits	L	T	P	Section (Group)
4	3	1	0	B.Tech. (IT, CS)

Course Module Details

Objective(s)

To develop understanding of modern methods of numerical linear algebra for solving linear systems, least squares problems, and the eigenvalue problem.

Pre-Requisites: None.

Description

- **Basics (7 hours):** Summary/recap of basic concepts from linear algebra and numerical analysis: matrices, operation counts. Matrix multiplication, block matrices, Matrix norms. Linear system sensitivity.
- **Matrix factorizations (5 hours):** Matrix factorizations. Cholesky factorization. QR factorization by Householder matrices and by Givens rotations.
- **LU factorization and Gaussian elimination (7 hours):** partial pivoting. Solving triangular systems by substitution. Solving full systems by factorization. Error analysis. Complete pivoting, rook pivoting. Numerical examples.
- **Sparse and banded linear systems (4 hours):** Storage schemes for banded and sparse matrices. LU factorization.
- **Linear least squares problem (4 hours):** Basic theory using singular value decomposition (SVD) and pseudoinverse. Numerical solution: normal equations. SVD and rank deficiency.
- **Iterative methods for linear systems Iterative methods (6 hours):** Jacobi, Gauss-Seidel and SOR iterations. Kronecker product. Krylov subspace methods, conjugate gradient method.

- **Eigenvalue problem (7 hours):** Basic theory, including perturbation results. Power method, inverse iteration. Similarity reduction. QR algorithm.

Learning Outcomes Expected:

On completion of the module, students will be able to

- construct some key matrix factorizations using elementary transformations,
- choose an appropriate numerical method to solve linear systems, least squares problems, and the eigenvalue problem,
- evaluate and compare the efficiency and numerical stability of different algorithms for solving linear systems, least squares problems, and the eigenvalue problem,
- design algorithms that exploit matrix structures such as triangularity, sparsity, banded structure, and symmetric positive definiteness,
- quantify the sensitivity of a linear system or least squares problem to perturbations in the data.

Contact Details: Dr. Indira Mishra, Department of Mathematics, IIITL, indira@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Trefethen, Lloyd N. and David Bau III. *Numerical Linear Algebra.* SIAM: Society for Industrial and Applied Mathematics, 1997. ISBN: 9780898713619.
2. G. Allaire, S. M. Kaber, *Numerical Linear Algebra*, Springer, 2008.
3. Phillipe G. Ciarlet, *Introduction to Numerical Linear Algebra and Optimisation*, Cambridge University Press, 1989.

- **References**

1. Timothy A. Davis. *Direct Methods for Sparse Linear Systems.* Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, 2006. ISBN 0-89871-613-6.
2. James W. Demmel. *Applied Numerical Linear Algebra.* Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, 1997.
3. Yousef Saad. *Iterative Methods for Sparse Linear Systems.* Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, second edition, 2003. ISBN 0-89871-534-2.

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Department of CS/IT

Semester: VII/Elective

Course Code: DSY7301E

Course Name: Dialogue System

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s) This course presents advanced problems and current state-of-the-art in the field of dialogue systems, voice assistants, and conversational systems (chatbots). After a brief introduction into the topic, the course will focus mainly on the application of machine learning – especially deep learning/neural networks – in the individual components of the traditional dialogue system architecture as well as in end-to-end approaches (joining multiple components together).

Pre-Requisites Probability, Natural language processing, Introduction to linguistics

Description

- **Introduction (8 Hours):** Dialogue systems applications, basic components of dialogue systems, knowledge representation in dialogue systems and data and evaluation
- **Data and Evaluation (8 Hours):** Preparing data for building dialogue systems, Available corpora/datasets, Annotation, Data splits, Evaluation metrics – subjective & objective, intrinsic & extrinsic and Significance checks
- **Natural Language Understanding (10 Hours):** Handling user requirements, meaning representation: grammars, frames, graphs, dialogue acts ("shallow parsing"), Rule-based NLU, Classification-based NLU (features, logistic regression, SVM), Sequence tagging (HMM, MEMM, CRF), Handling speech recognition noise
- **Dialogue System (8 Hours):** dialogue representation as a (Partially Observable), Markov Decision Process, dialogue state tracking, action selection, reinforcement learning, user simulation, deep reinforcement learning (using neural networks)

- **Response generation (NLG) (4 hours)**: Introduction to NLG, basic methods (templates), generation using neural networks.
- End-to-end dialogue systems (one network to handle everything) (4 Hours) : sequence-to-sequence systems, memory/attention-based systems, pretrained language models
- **Open-domain systems (chatbots) (8 Hours):** generative systems (sequence-to-sequence, hierarchical models), information retrieval, ensemble systems
- **Multimodal systems (5 Hours):** component-based and end-to-end systems, image classification, visual dialogue

Learning Outcomes Expected:

After completing the course, the student will be able to design end-to-end dialogue system. They will also be able to develop multimodal system.

Contact Details: Dr. Muskaan Singh, Department of CS, IIITL, muskaan@iiitl.ac.in

Courseware and Reference Books

You should be able to pass the course just by following the lectures, but here are some hints on further reading. There's nothing ideal on the topic as this is a very active research area, but some of these should give you a broader overview.

- **Recommended, though slightly outdated:**
  1. Gao et al.: Neural Approaches to Conversational AI. arXiv:1809.08267
- **Recommended, but might be a bit too brief:**
  1. Jurafsky & Martin: Speech & Language processing. 3rd ed. draft (chapter 24). this one is really brief, but a good starting point
  2. McTear: Conversational AI: Dialogue Systems, Conversational Agents, and Chatbots. Morgan & Claypool 2021.
  3. **Further reading:**
  4. McTear et al.: The Conversational Interface: Talking to Smart Devices. Springer 2016. good, detailed, but slightly outdated
  5. Jokinen & McTear: Spoken dialogue systems. Morgan & Claypool 2010. (good but outdated, some systems very specific to particular research projects)
  6. Rieser & Lemon: Reinforcement learning for adaptive dialogue systems. Springer 2011. (advanced, slightly outdated, project-specific)
  7. Lemon & Pietquin: Data-Driven Methods for Adaptive Spoken Dialogue Systems. Springer 2012.
  8. Skantze: Error Handling in Spoken Dialogue Systems. PhD Thesis 2007, Chap. 2. (good introduction into dialogue systems in general, albeit dated)
  9. current papers from the field (see links on lecture slides)

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Department of Information Technology

Semester: VI

Course Code: NSE6400E

Course Name: Network Security

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech. (IT and CS)

Course Module Details

Objective(s)

The main objective of this course is to provide learners with a baseline understanding of common network security threats, vulnerabilities, and risks. The course is also able to explain the various network security techniques & algorithms along with the main security protocols that enable their protection.

Pre-Requisites: Knowledge of Cryptography and Computer Programming would be of great help.

Description

- **Introduction to Network Security (2 hours):** Information & Network Security and Security goals, Attacks
- **Security Services (3 hours):** Authentication, Access Control, Data Confidentiality, Data Integrity, Non- Repudiation
- **Entity Authentication (4 hours):** Fixed Password, One Time Password, Properties of Identification Rule, Challenge-Response Protocol, Key Management Protocols
- **Key Distribution Center (6 hours):** Otway-Rees Protocol, Kerbrose, Zero Knowledge Proofs, Bio metric Authentication
- **Security at Network Layer & Transport Layer (5 hours):** IPSec, Encryption/ Decryption Algorithms of TLS, TLS Protocol and Phases, Difference between SSL / TLS

- **Security at Application Layer (8 hours):** SET Protocol, S/MIME, PGP
- **WLAN Security):** IEEE802.11 WLAN Overview, Security Issues: Security in MANET, VANET, WSN, & Cloud Security
- **IoT Security (6 hours):** Security Issues of IoT, IDS in IoT, Blockchain Technology
- **System Security (6 hours):** Intruders, Malicious software, and Firewalls

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand the fundamentals & concept of network security
- Design and analyse security protocols appropriate for a given environment
- demonstrate an understanding of security issues of IoT, Cloud, & any wireless ad-hoc networks

Contact Details: Dr. Brijesh Kumar Chaurasia, Department of Information Technology, IIITL, brijesh@iiitl.ac.in, brijeshchaurasia@ieee.org

Courseware and Reference Books

- **Text Books**

1. William Stallings, *Cryptography and Network Security: Principles and Practice*, Pearson Education Canada, 2020.
2. Chuck Easttom, *Modern Cryptography: Applied Mathematics for Encryption and Information Security*, McGraw-Hill Education, 2016.

- **References**

1. Nicholas Kolokotronis and Stavros Shiaeles, *Cyber-Security Threats, Actors, and Dynamic Mitigation*, CRC Press, 2021.
2. Keith Martin, *Cryptography: The Key to Digital Security, How It Works, and Why It Matters*, W. W. Norton & Company, 2020.
3. Forouzan, *Cryptography And Network Security — 3rd Edition*, Mc Graw Hill India, 2015.

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भारतीय सूचना प्रौद्योगिकी संस्थान, लखनऊ

Department of Management and Humanities

Semester: Elective

Course Code: EFA7400E

Course Name: Economic and Financial Analysis

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech.

Course Module Details

Objective(s)

To develop an understanding of the concepts and theories of Economics and acquire the ability to address application oriented issues. To understand dynamic nature of economic variables that influence decision making.

Pre-Requisites: Basic understanding of concepts of Business Economics.

Description

- **Introduction (6 hours):** Fundamental concepts, Time value of money, Cash flow and Time Diagrams, Choosing between alternative investment proposals.
- **Capital Budgeting (8 hours):** Concept, significance and limitations of Capital Budgeting, Methods of Economic analysis (Pay Back, ARR, NPV, IRR and B/C ratio) and the effect of borrowing on investment.
- **Depreciation (3 hours):** Meaning and methods of calculating depreciation (Straight line, Sum of years digit method, Reducing balance method, Annuity Method).
- **Introduction to National Income (5 hours):** National Income-Definition, Various concepts of National Income, Methods of Estimation, Significance of National Income estimation and its limitations.

- **Inflation (3 hours):** Definition, Process and Theories of Inflation and measures to control inflation.
- **Balance of Payment & Foreign Exchange Rate (4 hours):** Meaning, Types of Accounts in BOP, Deficit BOP, Foreign Exchange Rate determination, Appreciation and Depreciation of Foreign Currency
- **Economic Policy of 1991 (3 hours):** Economic policy of 1991-Introduction and changes in various economic policies by the Central Government (Current Affairs).
- **Financial Analysis and Planning-Simple Ratio Analysis (8 hours):** Sources of financial data, objective of financial analysis, financial ratios- types and use, limitations of Ratio Analysis.
- **Application of Cost Concepts (8 hours):** Cost Accounting – Introduction, Classification of costs, Methods of costing, Techniques of costing, Cost sheet and preparation of cost sheet, Break-even Analysis and its application, limitations.
- **Presentations / Group discussions: on current topics. (8 hours)**

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Compare the methods of economic analysis to evaluate a project viability.
- Evaluate different methods of depreciation.
- Understand the macro-economic environment.
- Analyse the financial statements with ratios for investment decisions.
- Analyse costs and their role in pricing

Contact Details: Dr. Varun Sharma, Department of Management and Humanities, IIIL, varun@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. Chan S. Park , *Fundamentals of Engineering Economics*, Pearson, 2021 .
  2. Pravin Kumar , *Fundamentals of Engineering Economics*, Wiley, 2012.
- **References**
  1. Arora M.N, *Cost Accounting*, Vikas Publications,2013.
  2. K Sharma and Gupta K Sashi, *Financial Management*, Kalyani Publications, 2014

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Department of Management and Humanities

Semester: Elective

Course Code: GBE7400E

Course Name: Global Business and Economy

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech.

Course Module Details

Objective(s)

An understanding of international business is essential for students in today's interdependent global world. This course will provide students with the knowledge, skills, and abilities to understand the global economic, political, cultural and social environment within which firms operate. It will examine the strategies and structures of international business and assess the special roles of an international business's various functions.

Pre-Requisites: Basic understanding of concepts of Business Economics.

Description

- **Unit I (8 hours):** Definition and Scope of International Business: Why companies do International Business, Domestic Business Vs International Business. Country Risk Analysis: Political Risk Analysis, Economic Risk Analysis, Socio-Cultural Risk Analysis, Legal Environment.
- **Unit II (8 hours):** International Trade, reasons countries trade with each other, impact of international trade on individual businesses and communities and propose solutions for minimizing any adverse effects.
- **Unit III (8 hours):** Foreign Direct Investment: Define Foreign Direct Investment (FDI) and its importance in the global economy, make generalizations about the impact of FDI on home and host countries and describe how companies decide to make FDI.

- **Unit IV (8 hours):** Balance of Trade and Balance of Payment: Trade Barrier, Tariff Barriers & Non-Tariff Barriers, Regional Trade Agreements: Bi- lateral Trade Agreements & Multi-lateral Trade Agreements,Foreign Exchange Rate determination, Appreciation and Depreciation of Foreign Currency.
- **Unit V (8 hours):** Globalization Overview: Meaning, how globalization creates linkages between nations and businesses, how the process of globalization creates opportunities and challenges for businesses, the benefits and drawbacks of globalization.
- **Unit VI (8 hours):** International Monetary System: Foreign exchange rates, International Monetary fund (IMF), International Bank for Reconstruction and Development (IBRD) and World Bank.
- **Presentations / Group discussions: on current topics. (8 hours)**

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Build a foundation in macroeconomics to make more informed business decisions.
- Learn distinctive approaches and frameworks that help you think about the world and organize information.
- Understand the most widely used international business terms and concepts.
- Understand the scope and challenges for entering into the international market along with the theories of International Trade.
- Understand the risk process before making a decision to enter an international market and market entry strategies.

Contact Details: Dr. Varun Sharma, Department of Management and Humanities, IIIL, varun@iiitl.ac.in

Courseware and Reference Books

- **Text Books**
  1. John J. Wild, Kenneth L. Wild, Jerry C. Y. Han , *International Business: The Challenges of Globalisation*, Pearson Prentice Hall, 2008.
  2. K Aswathappa , *International Business*, McGraw Hill, 2020.
- **References**
  1. Charles W Hill and Arun K Jain, *Competing in the Global Market Place*, Tata McGraw-Hill,2011.
  2. S.Tamer Cavusgil, Gary Knight and John R. Reisenberger, *International Business-Strategy, Management and the New Realities*, Pearson Publications.,2020

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Department of Management & Humanities

Semester: Elective

Course Code: BAN6400E

Course Name: Business Analytics

Credits	L	T	P	Section (Group)
4	4	0	0	B.Tech. (B.Tech. (IT, CS, CS-AI, & CSB))

Course Module Details

Objective(s)

Business analytics has the ability to generate business insights in today's data-rich environment. This course will provide students with a practical grasp of the key data analysis tools that may be used to generate these insights. Learn how to determine when to apply which business analytics strategy and how to make the best decision.

Pre-Requisites: There is as such no pre-requite for this course, however if student have the knowledge of basic probability and statistics that will be good.

Description

- **Unit 1- Introduction to Business Analytics (3 hours):** Concepts and Tools, Business Intelligence, Definitions and Solutions, An Introduction to Business Intelligence, Competing on Analytics
- **Unit 2- Data Preparation, Exploration and Data visualization (8 hours):** Data Warehouse, The Basics tools of Business Analysis, Emerging Areas in Analytics
- **Unit 3- Emerging Trends in Analytics (5 hours):** Web Analytics, Text Analytics, Mobile Analytics, Network Analytics
- **Unit 4- Data Segmentation Techniques (7 hours):** Classification methods, Naïve rule, Naïve Bayes, K-nearest neighbours, Decision Tree Analysis

- **Unit 5- Cluster Analysis (7 hours):** Hierarchical Clustering, K-means clustering
- **Unit 6- BA Applications in Marketing (5 hours):** Association Rules, Market Basket Analysis, Neural Network
- **Unit 7- Predictive Analytics (8 hours):** Multiple Regression, Regression Diagnostics, Logistic Regression
- **Unit 8- BA Applications in Financial services (5 hours):**

  Credit Risk Assessment, Credit Scoring Models
- **Unit 9- Modelling and Forecasting (8 hours):** ARIMA/MSARIMA, Forecast day-ahead, Peak Demand Forecast

Learning Outcomes Expected:

Numerous outcomes will be achieved upon completion of the course:

- Students will get a grasp of the various types of analytics and why they are critical in the business world.
- Students will acquire skills in data preparation, exploration, and visualization.
- Techniques for segmenting and clustering data into various groups, as well as data analysis, will be covered
- This course will teach students about Market Basket Analysis, Credit Risk Assessment, Credit Scoring Models, and other business analytics applications.
- Additionally, students will get an understanding of the numerous time series forecasting models that can be used in a variety of situations.

Contact Details: Dr. Niraj Kumar Vishvakarma, Department of Management & Humanities, IIIL, niraj@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

  1. Galit Shmueli, Nitin R. Patel and Peter C. Bruce , *Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner*, 2nd Edition, Wiley, 2010.
  2. James R. Evans, *Business Analytics Methods, Models, and Decisions*, 3rd Edition, Pearson, 2019.

- **References**

  1. Berson, A., Smith, S., and Thearling, K, *Building Data Mining Applications for CRM* , McGraw-Hill, Inc. 2000.
  2. Berry, M. J. A., and Linoff, G. S., *Mastering Data Mining: The Art and Science of Customer Relationship Management*, John Wiley & Sons, 2000.

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Department of CS/IT

Semester: Elective

Course Code: OTE7301E

Course Name: Optimization Techniques

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s):

- To develop the understanding of the concepts related to different optimization techniques including linear, non-linear, meta-heuristic algorithms, dynamic programming, among others, and their applications to real-life problems.
- To understand the theory of when and why these techniques work.

This will provide students with a sound background in the area and benefit those who wish to pursue doctoral or master level theses in this subject, or apply these techniques to their own areas.

Pre-Requisites: Probability, Basics of Programming Language (preferable Python)

Description

- **Mathematical preliminaries (6 Hours):** Linear algebra and matrices, Vector space, Eigen analysis, Elements of probability theory, Elementary multivariable calculus
- **Introduction (2 Hours):** Historical Development, Engineering applications of optimization, Statement of an optimization problem, Classification of optimization problems
- **Linear Programming (8 Hours):** A brief review of simplex and revised simplex algorithms, Bland's rule, duality theory, large scale linear programmes, computational complexity of simplex method, polynomial time algorithms— ellipsoidal and Karmarkar's methods

- **Non-linear Programming (8 Hours):** General constrained mathematical programming problems, KuhnTucker-Lagrangian necessary and sufficient conditions, interior point methods, standard algorithms like feasible direction and gradient projections convergence of the methods, convex programming problems, quadratic programming.
- **Integer Programming (6 Hours):** All integer and mixed integer programming problems, cutting planes and branch and bound algorithms, introduction to the ideas of NP-completeness, travelling salesman and other related problems
- **Single and Multi-objective Optimization (2 Hours):** Single vs. Multi-objective optimization techniques with evolutionary computing, dominance and non-dominance relationship. Case studies from real-life.
- **Nature Inspired optimization (8 Hours):** Traditional methods, Simulated Annealing, Genetic algorithms, Differential Evolution, Particle Swarm Optimization, Ant-Colony Optimization, Grey Wolf Optimization, Use-cases.

Learning Outcomes Expected:

After completing the course, the student will be able to

1. Learn efficient computational procedures to solve optimization problems.
2. Cast real-life minima/maxima problems into optimization framework
3. Identify appropriate optimization method to solve complex problems involved in real-life.

Contact Details: Dr. Naveen Saini, Department of CS, IIITL, naveen@iiitl.ac.in

Courseware and Reference Books

1. Rardin, Ronald L., *Optimization in Operations Research*, Pearson Education (2005).
2. Ravindran A, Phllips D.T. and Solberg J.J. *Operation Research: Principles and Practice*, John Wiley (2007)
3. R. Fletcher, *Practical methods of optimization*, 2nd Edition, Wiley, 2000, New York
4. E. K. P. Chong and S. Zak, *An introduction to optimization*, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore
5. D. Luenberger, *Linear and nonlinear programming*, 2nd Edition, 1984, Kluwer Academic Publisher, New York
6. Jorge Nocedal and Stephen Wright, *Numerical Optimization*. 2nd Edition. Springer, 2006
7. Deb, Kalyanmoy, *Multi-objective optimisation using evolutionary algorithms: an introduction*, 2011, Springer.

In addition to the above references, selection of papers from leading conferences and journals in optimization, as well as applied areas (see links on lecture slides) such as information theory, and machine learning can also be referred for details.