VIDYA JYOTHI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)

(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)

Aziz Nagar Gate, C.B. Post, Hyderabad - 500 075, Telangana.

Course Structure (R-25 Regulations)

Applicable from AY 2025-2026 Batch

B.Tech. in CSE (Data Science)

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B. Tech. in CSE (DATA SCIENCE)

Course Structure & Syllabus (R-25 Regulations)

Applicable from AY 2025-2026 Batch

II YEAR I SEMESTER

S.No.	Course Code	Course Title	L	T	P	Credits
1.		Probability & Statistics	3	0	0	3
2.		Discrete Mathematics	3	0	0	3
3.		Object Oriented Programming through Java	3	0	0	3
4.		Software Engineering	3	0	0	3
5.		Database Management Systems	3	0	0	3
6.		Computational Mathematics Lab	0	0	2	1
7.		Object Oriented Programming through Java Lab	0	0	2	1
8.		Software Engineering Lab	0	0	2	1
9.		Database Management Systems Lab	0	0	2	1
10.		Django	0	0	2	1
Total Credits			**15**	**0**	**10**	**20**

II YEAR II SEMESTER

S.No.	Course Code	Course Title	L	T	P	Credits
1.		Computer Organization and Architecture	3	0	0	3
2.		Operating Systems	3	0	0	3
3.		Algorithms Design and Analysis	3	0	0	3
4.		Computer Networks	3	0	0	3
5.		Machine Learning	3	0	0	3
6.		Innovation and Entrepreneurship	2	0	0	2
7.		Operating Systems Lab	0	0	2	1
8.		Computer Networks lab	0	0	2	1
9.		Machine Learning Lab	0	0	2	1
10.		Data Visualization- Power BI	0	0	2	1
11.		Indian Knowledge System	1	0	0	1
Total Credits			**18**	**0**	**8**	**22**

Dr. KSRK Sarma	Dr. A. Damodaram	Dr. V. Vijaya Kumar	Dr. P. V Subba Reddy	Dr. Y. C. A. P. Reddy
Dr. Satish Balantrapu	Md. Shafiuddin	Dr. D. Aruna Kumari	Dr. A. Obulesh	Dr. N. Anusha
Dr. RRS Ravi Kumar	Dr. D. Babu Rao	Dr. P. Sandhya	Kishore K	**R25 B.Tech. CSE (DS)**

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III YEAR I SEMESTER

S.No.	Course Code	Course Title	L	T	P	Credits
1.		Predictive Analytics	3	0	0	3
2.		Full Stack Development	3	0	0	3
3.		Introduction to Data Science	3	0	0	3
4.		Professional Elective-I	3	0	0	3
5.		Open Elective-I	2	0	0	2
6.		Predictive Analytics Lab	0	0	2	1
7.		Full Stack Development Lab	0	0	2	1
8.		Data Science Lab	0	0	2	1
9.		Field Based Research Project	0	0	4	2
10.		UI Design –Flutter	0	0	2	1
11.		Gender Sensitization Lab*/ Human Values and Professional Ethics*	1	0	0	1
Total Credits			**15**	**0**	**12**	**21**

III YEAR II SEMESTER

S.No	Course Code	Course Title	L	T	P	Credits
1.		Data Stream Processing	3	0	0	3
2.		Big Data Technologies	3	0	0	3
3.		Business Economics and Financial Analysis	3	0	0	3
4.		Professional Elective-II	3	0	0	3
5.		Open Elective – II	2	0	0	2
6.		Data Stream Processing Lab	0	0	2	1
7.		Big Data Technologies Lab	0	0	2	1
8.		Exploratory Data Analysis Lab	0	0	2	1
9.		Advanced English Communication Skills Laboratory	0	0	2	1
10.		Prompt Engineering	0	0	2	1
11.		Environmental Science	1	0	0	1
Total Credits			**14**	**0**	**10**	**20**

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IV YEAR I SEMESTER

S.No.	Course Code	Course Title	L	T	P	Credits
1		Data Stream Mining	3	0	0	3
2		Web and Social Media Analytics	3	0	0	3
3		Fundamentals of Management for Engineers	3	0	0	3
4		Professional Elective-III	3	0	0	3
5		Professional Elective – IV	3	0	0	3
6		Open Elective – III	2	0	0	2
7		Data Stream Mining Lab	0	0	2	1
8		Web and social media Analytics Lab	0	0	2	1
9		Industry Oriented Mini Project/ Summer Internship	0	0	4	2
		Total Credits	**17**	**0**	**8**	**21**

IV YEAR II SEMESTER

S.No.	Course Code	Course Title	L	T	P	Credits
1		Professional Elective – V	3	0	0	3
2		Professional Elective – VI	3	0	0	3
3		Project Work	0	0	28	14
		Total Credits	**6**	**0**	**28**	**20**

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PROFESSIONAL ELECTIVES

Professional Elective - I

	Software Testing Methodologies
	Adhoc & Sensor Networks
	Devops
	Distributed Systems

Professional Elective - II

	Blockchain Technology
	Software Project Management
	Vulnerability Assessment and Penetration Testing
	Generative AI

Professional Elective-III

	Computer Vision
	Social Media Mining
	Cryptography and Network Security
	Cloud Computing

Professional Elective-IV

	Augmented Reality & Virtual Reality
	Quantum Computing
	Robotic Process Automation
	Cyber Forensics

Professional Elective-V

	Nature Inspired Computing
	Internet of Things
	Mobile Application Development
	Human Computer Interaction

Professional Elective-VI

	High Performance Computing
	Edge Computing
	UI/UX design
	Distributed Databases

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9.		Database Management Systems Lab	0	0	2	1
10.		DJango	0	0	2	1
		Total Credits	**15**	**0**	**10**	**20**

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11.		Indian Knowledge System	1	0	0	1
		Total Credits	**18**	**0**	**8**	**22**

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DISCRETE MATHEMATICS

B.Tech. II Year I Sem.

L	T	P	C
3	0	0	3

Course Outcomes:

1. Understand and construct precise mathematical proofs
2. Apply logic and set theory to formulate precise statements
3. Analyze and solve counting problems on finite and discrete structures
4. Describe and manipulate sequences
5. Apply graph theory in solving computing problems

UNIT - I

Mathematical Logic: Introduction, Statements and Notation, Connectives & Truth Tables, Normal Forms (DNF, CNF, PDNF, PCNF)

UNIT – II

Theory of Inference for the Statement Calculus, The Predicate Calculus, Inference Theory of the Predicate Calculus

Set Theory: Introduction, Basic Concepts of Set Theory, Relations: Special Properties of Binary Relations, Equivalence Relations, Partially ordered relations, Hasse diagrams, Lattices.

UNIT - III

Functions: composition of functions, Inverse Functions

Algebraic structures: Algebraic systems-Examples and General Properties, Semi groups and Monoids, groups, sub groups, homomorphism, Isomorphism.

UNIT - IV

Elementary Combinatorics: Basics of Counting, Combinations and Permutations, Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutation with Constrained Repetitions, Binomial Coefficient, The Binomial and Multinomial Theorems, The Principle of Exclusion.

UNIT - V

Graph Theory: Basic Concepts, Isomorphism and Subgraphs, Trees and their Properties, Spanning Trees, Directed Trees, Binary Trees, Planar Graphs, Euler's Formula, Multi-graphs and Euler Circuits, Hamiltonian Graphs, Chromatic Numbers, The Four-Color Problem.

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TEXT BOOKS:

1. Discrete Mathematical Structures with Applications to Computer Science: J.P. Tremblay, R. Manohar, McGraw-Hill, 1st ed.
2. Discrete Mathematics for Computer Scientists & Mathematicians: Joe l. Mott, Abraham Kandel, Teodore P. Baker, Prentis Hall of India, 2nd ed.

REFERENCE BOOKS:

1. Discrete and Combinatorial Mathematics - an applied introduction: Ralph. P. Grimald, Pearson education, 5th edition.
2. Discrete Mathematical Structures: Thomas Kosy, Tata McGraw Hill Publishing co.

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OBJECT ORIENTED PROGRAMMING THROUGH JAVA

B.Tech. II Year I Sem.

L	T	P	C
3	0	0	3

Course Outcomes:

1. Demonstrate the behavior of programs involving the Basic Programming constructs like Control Structures, Constructors, String Handling and Garbage Collection.
2. Demonstrate the implementation of Inheritance (multilevel, hierarchical and multiple) by using extends and implements keywords
3. Use Multithreading concepts to develop Inter Thread Communication, and Handling Exceptions.
4. Understand the different types of File I/O, Exploring Strings & Java Collection Classes.
5. Develop Web Applications using JDBC and Servlets.

UNIT - I

Object Oriented thinking and Java Basics- OOP concepts, History of Java, Java buzzwords, data types, variables, operators, expressions, control statements, arrays, type casting, simple java program, concepts of classes, objects, constructors, methods, access control, this keyword, garbage collection, overloading methods and constructors, parameter passing, object Class and wrapper classes.

UNIT - II

Inner Classes in Java: Types of inner classes, Creating static / non-static inner classes, Local and anonymous inner classes.

Inheritance, Interfaces and Packages– Types of Inheritance, benefits of inheritance, super, final keyword with inheritance, method overriding, abstract classes. Defining and implementing interfaces.

Packages: Defining, Creating and Accessing a Package, Understanding CLASSPATH, importing packages.

UNIT - III

Exception handling and Multithreading-- Concepts of exception handling, benefits of exception handling, exception hierarchy, usage of try, catch, throw, throws and finally, built in exceptions, User Defined Exceptions. Differences between multithreading and multitasking, thread life cycle, creating threads, thread priorities, synchronizing threads, inter thread communication, thread groups, daemon threads.

UNIT - IV

Exploring String, StringBuffer, StringBuilder classes and StringTokenizer. **Java.io package:** File, Byte Streams: InputStream, OutputStreams, FileInputStream, FileOutputStream, Character Streams: Reader, Writer, FileReader, FileWriter, BufferedReader, BufferedWriter, InputStreamReader.

java.util Package- Collection Interfaces: List,Set, Map. Collection classes: LinkedList, TreeSet, HashMap, Enumerator, Iterator, ListIterator, Calendar, Random, Scanner, Comparator, Comparable.

UNIT - V

Java Servlets: Overview of Java Servlet, Servlet Life cycle, Request and Response methods, Servlet Configuration, Servlet Context, Approaches to Session tracking, Servlet Collaboration.
Database Connections: Introduction to JDBC, JDBC Drivers, Connecting to a Database using JDBC.

TEXT BOOKS:

1. Java the complete reference, 13th edition, Herbert Schildt, Dr. Denny Coward, Mc Graw Hill.
2. Understanding OOP with Java, updated edition, T. Budd, Pearson education.

REFERENCE BOOKS:

1. An Introduction to programming and OO design using Java, J.Nino and F.A. Hosch, John Wiley & sons.
2. An Introduction to OOP, third edition, T. Budd, Pearson education.
3. Introduction to Java programming, Y. Daniel Liang, Pearson education.
4. An introduction to Java programming and object-oriented application development, R.A. Johnson- Thomson.
5. Core Java 2, Vol 1, Fundamentals, Cay.S. Horstmann and Gary Cornell, eighth Edition, Pearson Education.

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SOFTWARE ENGINEERING

B.Tech. II Year I Sem.

L	T	P	C
3	0	0	3

Course Outcomes

- Ability to translate end-user requirements into system and software requirements, using e.g.
- UML, and structure the requirements in a Software Requirements Document (SRD).
- Identify and apply appropriate software architectures and patterns to carry out high level design of a system and be able to critically compare alternative choices.
- Will have experience and/or awareness of testing problems and will be able to develop a simple testing report

UNIT - I

Introduction to Software Engineering: The evolving role of software, changing nature of software, software myths. A Generic view of process: Software engineering- a layered technology, a process framework, the capability maturity model integration (CMMI).
Process Models: The waterfall model, Spiral model, Incremental Process Models, Concurrent Models, Component based development and Agile Development.

UNIT - II

Software Requirements: Functional and non-functional requirements, user requirements, system requirements, interface specification, the software requirements document.
Requirements Engineering Process: Feasibility studies, requirements elicitation and analysis, requirements validation, requirements management.

UNIT - III

Design Engineering: Design process and design quality, design concepts, the design model.
Creating an Architectural Design: software architecture, data design, architectural styles and patterns, architectural design, conceptual model of UML, basic structural modeling, use case diagrams, class diagrams, sequence diagrams, collaboration diagrams, activity diagrams and component diagrams.

UNIT - IV

Testing Strategies: A strategic approach to software testing, test strategies for conventional software, black-box and white-box testing, validation testing, system testing, the art of debugging.
Metrics for Process and Products: Software measurement, metrics for software quality.

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UNIT - V

Risk Management: Reactive Vs proactive risk strategies, software risks, risk identification, risk projection, risk refinement, RMMM.
Quality Management: Quality concepts, software quality assurance, software reviews, formal technical reviews, statistical software quality assurance, software reliability, the ISO 9000 quality standards.

TEXT BOOKS:

1. Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th edition, McGraw Hill International Edition.
2. Software Engineering- Sommerville, 7th edition, Pearson Education.
3. The unified modeling language user guide, Grady Booch, James Rumbaugh, Ivar Jacobson, Pearson Education.

REFERENCE BOOKS:

1. Software Engineering, an Engineering approach- James F. Peters, Witold Pedrycz, John Wiley.
2. Software Engineering principles and practice- Waman S Jawadekar, The McGraw-Hill Companies.
3. Fundamentals of object-oriented design using UML Meiler page-Jones: Pearson Education.
4. Fundamentals of Software Engineering-Rajib Mall, PHI.

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DATABASE MANAGEMENT SYSTEMS

L	T	P	C
3	0	0	3

B.Tech. II Year I Sem.

Course Outcomes:

At the end of the course, student will be able to:

1. Gain knowledge of fundamentals of DBMS, Database Design and Normal Forms
2. Master the basics of SQL for retrieval and management of data.
3. Be acquainted with the basics of transaction processing and concurrency control.
4. Familiarity with database storage structures and access techniques

UNIT-I

Database System Applications: A Historical Perspective, File Systems versus a DBMS, the Data Model, Levels of Abstraction in a DBMS, Data Independence, Structure of a DBMS

Introduction to Database Design: Database Design and ER Diagrams, Entities, Attributes, and Entity Sets, Relationships and Relationship Sets, Additional Features of the ER Model, Conceptual Design With the ER Model

UNIT-II

Introduction to the Relational Model: Integrity constraint over relations, enforcing integrity constraints, querying relational data, logical database design, introduction to views, destroying/altering tables and views.

Relational Algebra, Tuple relational Calculus, Domain relational calculus.

UNIT-III

SQL: QUERIES, CONSTRAINTS, TRIGGERS: form of basic SQL query, UNION, INTERSECT, and EXCEPT, Nested Queries, aggregation operators, NULL values, complex integrity constraints in SQL, triggers and active databases.

Schema Refinement: Problems caused by redundancy, decompositions, problems related to decomposition, reasoning about functional dependencies, FIRST, SECOND, THIRD normal forms, BCNF, lossless join decomposition, multivalued dependencies, FOURTH normal form, FIFTH normal form.

UNIT-IV

Transaction Concept, Transaction State, Implementation of Atomicity and Durability, Concurrent Executions, Serializability, Recoverability, Implementation of Isolation, Testing for serializability, Lock Based Protocols, Timestamp Based Protocols, Validation- Based Protocols.

UNIT-V

Hashing: Hash Based Indexing, Tree based Indexing, Comparison of File Organizations, Indexes- Intuitions for tree Indexes, Indexed Sequential Access Methods (ISAM)

B+ Trees: A Dynamic Index Structure.

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TEXT BOOKS:

1. Database System Concepts, Silberschatz, Korth, McGraw hill, V edition.3rd Edition
2. Database Management Systems, Raghurama Krishnan, Johannes Gehrke, Tata Mc Graw Hill

REFERENCE BOOKS:

1. Database Systems design, Implementation, and Management, Peter Rob & Carlos Coronel 7th Edition.
2. Fundamentals of Database Systems, Elmasri Navrate, Pearson Education
3. Introduction to Database Systems, C. J. Date, Pearson Education
4. Oracle for Professionals, The X Team, S.Shah and V. Shah, SPD.
5. Database Systems Using Oracle: A Simplified guide to SQL and PL/SQL, Shah, PHI.
6. Fundamentals of Database Management Systems, M. L. Gillenson, Wiley Student Edition.

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OBJECT ORIENTED PROGRAMMING THROUGH JAVA LAB

B.Tech. II Year I Sem.

L	T	P	C
0	0	2	1

Course Outcomes:

1. Able to Write Programs for Solving Real World Problems
2. Able to Write Programs using Abstract Classes.
3. Able to Write Multithreaded Programs.
4. Able to Write the Programs using the Java Collection Framework.
5. Able to Create Web Applications using Servlets and JDBC.

List of Experiments:

1. Write a Java Program to accept Student Name and Roll Number as command Line Arguments and Display the output.
2. Write a Java Program that prompts the user for an integer and then prints out all prime numbers up to that integer.
3. Write a Java Program that uses both recursive and non recursive functions to print the nth value in the Fibonacci sequence.
4. Write a Java Program to create an Employee class to read and display the data (emp_id, emp_name, Department, salary, experience) using constructor and method.
5. Write a Java Program to illustrate method and constructor overloading.
6. Write a Java Program to multiply two given matrices by passing objects as parameters.
7. Write a Java Program to illustrate different types of inheritances.
8. Write a java Program to illustrate Method Overriding.
9. Write a Java Program to create an abstract class named Shape that contains two integers and an empty method named print Area (). Provide three classes named Rectangle, Triangle, and Circle such that each one of the classes extends the class Shape. Each one of the classes contains only the method print Area () that prints the area of the given shape.
10. Write a Java Program to illustrate the use of Creating and Importing Packages.
11. Write a Java Program to handle Multiple Exceptions.
12. Write a Java Program to create User Defined Exceptions.
13. Write a Java Program that implements a multi-thread application that has three threads. The first thread generates a random integer every 1 second and if the value is even, the second thread computes the square of the number and prints. If the value is odd, the third thread will print the value of the cube of the number.

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14. Write a Java Program that implements the Producer – Consumer Problem using the concept of Inter Thread Communication.
15. Write a Java Program to list all the files in a directory including the files present in all its subdirectories.
16. Write a Java Program that loads names and phone numbers from a text file where the data is organized as one line per record and each field in a record is separated by a tab (\t). It takes a name or phone number as input and prints the corresponding other value from the hash table (hint: use hash tables).
17. Write a Java Program that reads a line of integers, and then displays each integer, and the sum of all the integers
18. Write a Java Program to make frequency count of words in a given text
19. Write a Java Program to establish Database connection and execute queries using JDBC.
20. Installation and Configuration of Tomcat and deploy a simple "Hello World" Servlet.

TEXT BOOKS:

1. Java for Programmers, P. J. Deitel and H. M. Deitel, 10th Edition Pearson education.
2. Thinking in Java, Bruce Eckel, Pearson Education.

REFERENCE BOOKS

1. Java Programming, D. S. Malik and P. S. Nair, Cengage Learning.
2. Core Java, Volume 1, 9th edition, Cay S. Horstmann and G Cornell, Pearson.

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SOFTWARE ENGINEERING LAB

B.Tech. II Year I Sem.

L	T	P	C
0	0	2	1

Course Outcomes:

- Ability to translate end-user requirements into system and software requirements
- Ability to generate a high-level design of the system from the software requirements
- Will have experience and/or awareness of testing problems and will be able to develop a simple testing report

List of Experiments

Do the following seven exercises for any two projects given in the list of sample projects or any other Projects:

1. Development of problem statements.
2. Preparation of Software Requirement Specification Document, Design Documents and Testing Phase related documents.
3. Preparation of Software Configuration Management and Risk Management related documents.
4. Study and usage of any Design phase CASE tool
5. Performing the Design by using any Design phase CASE tools.
6. Develop test cases for unit testing and integration testing
7. Develop test cases for various white box and black box testing techniques.

Sample Projects:

1. Passport automation System
2. Book Bank
3. Online Exam Registration
4. Stock Maintenance System
5. Online course reservation system
6. E-ticketing
7. Software Personnel Management System
8. Credit Card Processing
9. E-book management System.
10. Recruitment system

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TEXT BOOKS:

1. Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th edition, McGraw Hill International Edition.
2. Software Engineering- Sommerville, 7th edition, Pearson Education.
3. The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education.

REFERENCE BOOKS:

1. Software Engineering, an Engineering approach- James F. Peters, Witold Pedrycz, John Wiley.
2. Software Engineering principles and practice- Waman S Jawadekar, The McGraw-Hill

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DATABASE MANAGEMENT SYSTEMS LAB

B.Tech. II Year I Sem.

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Course Outcomes:

- Design database schema for a given application and apply normalization
- Acquire skills in using SQL commands for data definition and data manipulation.
- Develop solutions for database applications using procedures, cursors and triggers

List of Experiments:

1. Concept design with E-R Model
2. Relational Model
3. Normalization
4. Practicing DDL commands
5. Practicing DML commands
6. A) Querying (using ANY, ALL, UNION, INTERSECT, JOIN, Constraints etc.) B) Nested, Correlated subqueries
7. Queries using Aggregate functions, GROUP BY, HAVING and Creation and dropping of Views.
8. Triggers (Creation of insert trigger, delete trigger, update trigger)
9. Procedures
10. Usage of Cursors

TEXT BOOKS:

1. Database Management Systems, Raghurama Krishnan, Johannes Gehrke, Tata Mc Graw Hill,3rd Edition
2. Database System Concepts, Silberschatz, Korth, McGraw Hill, V edition.

REFERENCES BOOKS:

1. Database Systems design, Implementation, and Management, Peter Rob & Carlos Coronel 7th Edition.
2. Fundamentals of Database Systems, Elmasri Navrate, Pearson Education
3. Introduction to Database Systems, C.J. Date, Pearson Education
4. Oracle for Professionals, The X Team, S. Shah and V. Shah, SPD.
5. Database Systems Using Oracle: A Simplified guide to SQL and PL/SQL, Shah, PHI.
6. Fundamentals of Database Management Systems, M. L. Gillenson, Wiley Student Edition.

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DJANGO

L	T	P	C
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B.Tech II Year I Semester

Course Outcomes:

At the end of the course, student will be able to:

1. Design and Develop a responsive Web Application using HTML & CSS.
2. Build a responsive Web Application using Java Script, CSS, Flex & Grid.
3. Demonstrate understanding of the Django Framework
4. Implement Mailing, Cache and Session Management in Django Framework
5. Analyze, Design, Develop and Implement complete Web Applications using Django Framework

LIST OF EXPERIMENTS:

1. Build a Responsive Web Application for Registration Form, which contains User Name, Password, Date of Birth, Gender, Mail-id, Contact Number, Address and Submit Button.
2. Write a JavaScript Program to Validate Registration Page using Regular Expression.
3. Build a Responsive Web Application for Shopping Cart with Registration, Login, Catalog and Cart Pages using CSS3 features, Flex and Grid.
4. Basics of Django Framework & Installation of required Software's.
5. Create a shopping cart web application and add a customized admin page for product catalog management for Experiment 3
6. Demonstrate Cache, Session Management for Student Login Application.
7. Create a Quiz Application using Django Framework along with SQLite3.
8. Create a Django application using generic views and forms
9. Create an Application for Working with Mails using Django Framework
10. Create an application that fetches the weather information from openweathermap.org and the display the current and historical weather information using graphical representation using chart.js implement using Django
11. **Case Study:** Django Application for VJIT Student Portal and deploy it into GitHub.

REFERENCE BOOKS:

1. "Web Technologies: HTML, CSS, JavaScript" *Uttam K. Roy*
2. "Django for Beginners: Build Websites with Python and Django" *William S. Vincent*
3. "Python Web Development with Django" *Jeff Forcier, Paul Bissex, Wesley Chun*

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COMPUTER ORGANIZATION AND ARCHITECTURE

B.Tech. II Year II Sem.

L	T	P	C
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Course Outcomes:

At the end of the course, student will be able to:

1. Understand the basics of instruction sets and their impact on processor design.
2. Demonstrate an understanding of the design of the functional units of a digital computer system.
3. Evaluate cost performance and design trade-offs in designing and constructing a computer processor including memory.
4. Design a pipeline for consistent execution of instructions with minimum hazards.
5. Recognize and manipulate representations of numbers stored in digital computers

UNIT-I

Boolean Algebra and Logic Gates: Binary codes, Binary Storage and Registers, Binary logic, Digital logic gates.

Data Representation: Data types, Complements, Fixed Point Representation, Floating Point Representation

Digital Computers: Introduction, Block diagram of Digital Computer, Definition of Computer Organization, Computer Design and Computer Architecture.

UNIT-II

Combinational Logic: Combinational Circuits, Analysis procedure Design procedure, Binary Adder Subtractor Decimal Adder, Binary multiplier, magnitude comparator, Decoders, Encoders, Multiplexers, HDL for combinational circuits.

Sequential Logic: Sequential circuits, latches, Flip-Flops Analysis of clocked sequential circuits, state Reduction and Assignment, Design Procedure. Registers, shift Registers, Ripple counters, synchronous counters, other counters.

UNIT-III

Register Transfer Language and Micro operations: Register Transfer language, Register Transfer, Bus and memory transfers, Arithmetic Micro operations, logic micro operations, shift micro operations, Arithmetic logic shift unit.

Basic Computer Organization and Design: Instruction codes, Computer Registers Computer instructions, Timing and Control, Instruction cycle, Memory Reference Instructions, Input – Output and Interrupt.

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UNIT-IV

Microprogrammed Control: Control memory, Address sequencing, micro program example, design of control unit.

Central Processing Unit: General Register Organization, Instruction Formats, Addressing modes, Data Transfer and Manipulation, Program Control.

Computer Arithmetic: Addition and subtraction, multiplication Algorithms, Division Algorithms, Floating – point Arithmetic operations. Decimal Arithmetic unit, Decimal Arithmetic operations.

UNIT-V

Input-Output Organization: Input-Output Interface, Asynchronous data transfer, Modes of Transfer, Priority Interrupt Direct memory Access.

Memory Organization: Memory Hierarchy, Main Memory, Auxiliary memory, Associate Memory, Cache Memory.

TEXT BOOKS:

1. Digital Design – M. Morris Mano, Third Edition, Pearson/PHI.
2. Computer System Architecture – M. Morris Mano, Third Edition, Pearson/PHI.

REFERENCE BOOKS:

1. Switching and Finite Automata Theory, ZVI. Kohavi, Tata Mc Graw Hill.
2. Computer Organization – Carl Hamacher, Zvonks Vranesic, SafeaZaky, 5th Edition, McGraw Hill.
3. Computer Organization and Architecture – William Stallings Sixth Edition, Pearson/PHI.
4. Structured Computer Organization – Andrew S. Tanenbaum, 4th Edition, PHI/Pearson.

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OPERATING SYSTEMS

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B.Tech. II Year II Sem.

Course Outcomes:

At the end of the course, student will be able to:

1. Will be able to control access to a computer and the files that may be shared
2. Demonstrate the knowledge of the components of computers and their respective roles in computing.
3. Ability to recognize and resolve user problems with standard operating environments.
4. Gain practical knowledge of how programming languages, operating systems, and architectures interact and how to use each effectively.

UNIT-I

Operating System: Introduction, Structures - Simple Batch, Multiprogrammed, Time-shared, Personal Computer, Parallel, Distributed Systems, Real-Time Systems, System components, Operating System services, System Calls

Process: Process concepts, Process Control block (PCB), Operations on processes, Cooperating Processes, Threads

UNIT-II

CPU Scheduling: Scheduling Criteria, Scheduling Algorithms, Multiple -Processor Scheduling, System call interface for process management-fork, exit, wait, waitpid, exec

Process Management and Synchronization: The Critical Section Problem, Synchronization Hardware, Semaphores, and Classical Problems of Synchronization, Critical Regions, Monitors

UNIT-III

Memory Management and Virtual Memory: Logical versus Physical Address Space, Swapping, Contiguous Allocation, Paging, Segmentation, Segmentation with Paging, Demand Paging, Page Replacement, Page Replacement Algorithms.

UNIT-IV

Interprocess Communication Mechanisms: IPC between processes on a single computer system, IPC between processes on different systems, using pipes, FIFOs, message queues, shared memory.

File System Interface and Operations: Access methods, Directory Structure, Protection, File System Structure, Allocation methods, Free-space Management. Usage of open, create, read, write, close, lseek, stat, ioctl system calls.

UNIT-V

Deadlocks: System Model, Deadlocks Characterization, Methods for Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, and Recovery from Deadlock

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TEXT BOOKS:

1. Operating System Principles- Abraham Silberchatz, Peter B. Galvin, Greg Gagne 7th Edition, John Wiley
2. Advanced programming in the UNIX environment, W.R. Stevens, Pearson education.

REFERENCE BOOKS:

1. Operating Systems- Internals and Design Principles, William Stallings, Fifth Edition–2005, Pearson Education/PHI
2. Operating System A Design Approach- Crowley, TMH.
3. Modern Operating Systems, Andrew S. Tanenbaum 2nd edition, Pearson/PHI
4. UNIX programming environment, Kernighan and Pike, PHI/ Pearson Education
5. UNIX Internals -The New Frontiers, U. Vahalia, Pearson Education.

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ALGORITHMS DESIGN AND ANALYSIS

B.Tech. II Year II Sem.

L	T	P	C
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Course Outcomes:

At the end of the course, student will be able to:

1. Apply Space and Time Complexity Analysis using Asymptotic Notations.
2. Design Divide-and-Conquer Algorithms and critically assess their runtime and space trade-offs.
3. Device Backtracking and Dynamic Programming solutions.
4. Apply Greedy methods and Graph Traversal Algorithms
5. Analyze and Design Branch-and-Bound algorithms for NP-Hard problems

UNIT-I

Introduction: Algorithm, Performance Analysis-Space complexity, Time complexity, Asymptotic Notations- Big oh notation, Omega notation, Theta notation, and Little oh notation.
Divide and Conquer: General method, applications-Binary search, Quick sort, Merge sort, Strassen's matrix multiplication.

UNIT-II

Disjoint Sets: Disjoint set operations, union and find algorithms, Priority Queue- Heaps, Heapsort
Backtracking: General method, applications, n-queens problem, sum of subsets problem, graph coloring, Hamiltonian cycles.

UNIT-III

Dynamic Programming: General method, applications- Optimal binary search tree, 0/1 knapsack problem, All pairs shortest path problem, Traveling salesperson problem, Reliability design.

UNIT-IV

Greedy method: General method, applications- Job sequencing with deadlines, knapsack problem, Minimum cost spanning trees, Single source shortest path problem. **Basic Traversal and Search Techniques:** Techniques for Binary Trees, Techniques for Graphs, Connected components, Biconnected components.

UNIT-V

Branch and Bound: General method, applications - Travelling salesperson problem, 0/1 knapsack problem - LC Branch and Bound solution, FIFO Branch and Bound solution. **NP-Hard and NP-Complete problems:** Basic concepts, non-deterministic algorithms, NP - Hard and NP-Complete classes, Cook's theorem.

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TEXT BOOKS:

1. Fundamentals of Computer Algorithms, Ellis Horowitz, Satraj Sahni, and Rajasekaran, University Press.

REFERENCE BOOKS:

1. Design and Analysis of algorithms, Aho, Ullman, and Hopcroft, Pearson education.
2. Introduction to Algorithms, second edition, T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C.Stein, PHI Pvt. Ltd./ Pearson Education.
3. Algorithm Design: Foundations, Analysis and Internet Examples, M.T. Goodrich and R. Tamassia, John Wiley and Sons.

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COMPUTER NETWORKS

B.Tech II Year II Semester

L	T	P	C
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Course Outcomes:

At the end of the course, student will be able to:

1. Gain the knowledge of the basic computer network technology.
2. Gain the knowledge of the functions of each layer in the ISO-OSI and TCP/IP reference model.
3. Obtain the skills of subnetting and routing mechanisms.
4. Familiarity with the essential protocols of computer networks, and how they can be applied in network design and implementation.
5. Understanding working of the protocols through traces captured by a packet sniffer

UNIT-I

Introduction: The Internet, Protocol, Network Edge, Access Networks, Network Core, Packet Switching, Circuit Switching, Delay, Loss, and Throughput in Packet-Switched Networks, Protocol reference models: ISO-OSI, TCP/IP, Types of Network attacks, History of Computer Networking and the Internet.

UNIT-II

Application Layer: Principles of Network Applications, Network Application Architectures, Processes Communicating, Transport Services Available to Applications, Transport Services Provided by the Internet, Application-Layer Protocols, The Web and HTTP, File Transfer: FTP, Electronic Mail in the Internet, SMTP, DNS, Peer-to-Peer Applications, Socket Programming: Creating Network Applications.

UNIT-III

Transport Layer: Transport-Layer Services, Multiplexing and Demultiplexing, Connectionless Transport: UDP, Principles of Reliable Data Transfer, Building a Reliable Data Transfer Protocol, Pipelined Reliable Data Transfer Protocols, Go-Back-N (GBN), Selective Repeat (SR), Connection-Oriented Transport: TCP, The TCP Connection, Segment Structure, Round-Trip Time Estimation and Timeout, Reliable Data Transfer, Flow Control, TCP Connection Management, Principles of Congestion Control, TCP Congestion Control, Fairness.

UNIT-IV

Network Layer: Data and Control plane, Forwarding and Routing, Network Service Models, Virtual Circuit and Datagram Networks, Router working, The Internet Protocol (IP): Forwarding and Addressing in the Internet, Datagram Format, IPv4 Addressing, Internet Control Message Protocol (ICMP), IPv6, IP Security, Routing Algorithms- The Link-State (LS) Routing Algorithm, The Distance Vector (DV) Routing Algorithm, Hierarchical Routing, Routing in the Internet-Intra-AS Routing in the Internet: RIP, Intra-AS Routing in the Internet: OSPF, Inter-AS Routing: BGP, Broadcast and Multicast Routing, Broadcast Routing Algorithms, Multicasting.

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UNIT-V

The Link Layer: The Services Provided by the Link Layer, Error-Detection and -Correction Techniques- Parity Checks, Checksum Methods, Cyclic Redundancy Check (CRC), Hamming code, Multiple Access Links and Protocols, Channel Partitioning Protocols, Random Access Protocols, ARP, Ethernet, Link-Layer Switches, Virtual Local Area Networks (VLANs), Wireless network characteristics, Wireless LAN.

TEXT BOOKS:

1. Computer Networking: A Top-Down Approach – James F.Kurose, Keith W. Ross, Pearson
2. Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson/PHI

REFERENCE BOOKS:

1. Data Communications and Networking – Behrouz A. Forouzan. Third Edition TMH.

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MACHINE LEARNING

B.Tech. II Year II Sem.

L	T	P	C
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Course Outcomes:

At the end of the course, student will be able to:

1. Distinguish between, supervised, unsupervised and semi-supervised learning.
2. Evaluate the algorithms for model building and evaluations.
3. Understand various classification and Regression algorithms
4. Understand the various unsupervised learning algorithms
5. Design the artificial neural networks using various activation functions.

UNIT-I

Introduction to Machine Learning: Types of Human learning, machine learning process, Well-posed learning problem, Types of machine learning and comparison, applications of machine learning.

Model Preparation, Evaluation and feature engineering: Machine learning activities, Types of data in machine learning, dataset understanding, plotting and exploration, checking data quality, remediation, data pre-processing, selecting a model, predictive and descriptive models, supervised learning model training, cross-validation and boot strapping, lazy vs eager learner, interpreting the model- underfitting, overfitting, bias-variance trade-off.

UNIT-II

Feature Engineering: Feature transformation - feature construction, feature extraction by PCA, SVD, LDA. Feature subset selection – feature relevancy and redundancy measures. Feature selection process and approaches.

Review of Probability concepts: joint probability, conditional probability, bayes rule, Common discrete and continuous distributions, dealing with multiple random variables, Bayesian belief network.

UNIT-III

Supervised Learning: Introduction to supervised learning,

Regression: Introduction of regression, Regression algorithms: Simple linear regression, Multiple linear regression, Polynomial regression model, Logistic regression, Maximum likelihood estimation.

Classification: Classification model and learning steps, Classification algorithms: Naïve Bayes classifier, Distance measures, k-Nearest Neighbor (kNN), Decision tree, Support vector machines, Kernel trick, Random Forest.

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UNIT-IV

Unsupervised Learning: Introduction to unsupervised learning, Unsupervised vs supervised learning, Application of unsupervised learning, Clustering and its types, Partitioning method: k-Means and KMedoids, Hierarchical clustering, Density-based methods – DBSCAN.

Parameter for evaluating performance of classification, regression, and clustering model. Improving performance of a model.

UNIT-V

Artificial Neural Network: Biological neuron, Artificial neuron, Weights, Bias, Activation functions – linear, sigmoid, tanh, softmax, ReLU, LeakyReLU, Swish, Neural network architecture, Perceptron – Single layer and Multilayer Perceptron, Learning process in ANN- Feedforward Learning Process, Back Propagation algorithm.

TEXT BOOKS:

1. Saikat Dutt, S. Chjandramouli, Das – Machine Learning, Frist Edition, Pearson
2. M N Murty, Anathanarayana V S – Machine Learning, First Edition, University Press
3. Tom M Mitchell, —Machine Learning, First Edition, McGraw Hill Education, 2013.

REFERENCE BOOKS:

1. Stephen Marsland, —Machine Learning – An Algorithmic Perspective, Second Edition,
2. Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
3. Artificial Neural Networks, B. Yegnanarayana, PHI Learning Pvt. Ltd., 2009

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OPERATING SYSTEMS LAB

B.Tech. II Year II Sem.

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Course Outcomes:

At the end of the course, student will be able to:

1. Simulate and implement operating system concepts such as scheduling, deadlock management, file management and memory management.
2. Able to implement C programs using Unix system calls.

LIST OF EXPERIMENTS:

1. Write C programs to simulate the following CPU Scheduling Algorithms
   a) FCFS b) SJF c) Round Robin d) Priority
2. Write Programs using the I/O System Calls of UNIX/LINUX Operating System (open, read, write, close, lseek, stat, fork, exit)
3. Write a C Program to implement the Producer – Consumer Problem using Semaphores using UNIX/LINUX System Calls.
4. Write C programs to simulate the following Memory Management Techniques
   a) Paging b) Segmentation
5. Write C programs to simulate Page Replacement Policies
   a) FCFS b) LRU c) Optimal
6. Write C programs to illustrate the following IPC mechanisms
   a) Pipes b) FIFOs c) Message Queues d) Shared Memory
7. Write a C program to simulate Bankers Algorithm for Deadlock Avoidance.

TEXT BOOKS:

1. Operating System Principles- Abraham Silberchatz, Peter B. Galvin, Greg Gagne 7th Edition, John Wiley.
2. Advanced programming in the Unix environment, W. R. Stevens, Pearson education.

REFERENCE BOOKS:

1. Operating Systems – Internals and Design Principles, William Stallings, Fifth Edition– 2005, Pearson Education/PHI.
2. Operating System - A Design Approach-Crowley, TMH.
3. Modern Operating Systems, Andrew S Tanenbaum, 2nd edition, Pearson/PHI.
4. UNIX Programming Environment, Kernighan and Pike, PHI/Pearson Education.
5. UNIX Internals: The New Frontiers, U. Vahalia, Pearson Education.

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COMPUTER NETWORKS LAB

B.Tech II Year II Semester

L	T	P	C
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Course Outcomes:

At the end of the course, student will be able to:

- To be able to work with different network tools
- Implement Encoding and Decoding techniques used in presentation layer
- Implement and analyze routing and congestion issues in network design.
- Analyze error detection and error correction codes.
- Implement data link layer farming methods

LIST OF EXPERIMENTS:

1. Wireshark
   i. Packet Capture Using Wire shark
   ii. Starting Wire shark
   iii. Viewing Captured Traffic

1. Implement Dijsktra's algorithm to compute the shortest path through a network
2. Take an example subnet of hosts and obtain a broadcast tree for the subnet.
3. Implement distance vector routing algorithm for obtaining routing tables at each node
4. Write a program for congestion control using Leaky bucket algorithm.
5. Write a program for frame sorting techniques used in buffers.
6. Implement the data link layer framing methods such as character stuffing and bit stuffing
7. Write a program to compute CRC code for the polynomials CRC-12, CRC-16 and CRC CCI
8. Write a program to Implement hamming code algorithm
9. Develop a simple data link layer that performs the flow control using the sliding window protocol, and loss recovery using the Go-Back-N mechanism
10. Configure the Local Area Network using Packet Tracer

TEXT BOOKS:

1. Computer Networks, Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI

REFERENCE BOOKS:

1. An Engineering Approach to Computer Networks, S.Keshav, 2nd Edition, Pearson Education
2. Data Communications and Networking – Behrouz A. Forouzan. 3rd Edition, TMH.

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MACHINE LEARNING LAB

B.Tech. II Year II Sem.

L	T	P	C
0	0	2	1

Course Outcomes:
At the end of the course, student will be able to:

1. Understand modern notions in predictive data analysis
2. Select data, model selection, model complexity and identify the trends
3. Understand a range of machine learning algorithms along with their strengths and weaknesses
4. Build predictive models from data and analyze their performance

LIST OF EXPERIMENTS:

1. Write a python program to compute Central Tendency Measures: Mean, Median, Mode, Measure of Dispersion: Variance, Standard Deviation
2. Study of Python Basic Libraries such as Statistics, Math, Numpy and Scipy
3. Study of Python Libraries for ML application such as Pandas and Matplotlib
4. Write a Python program to implement Simple Linear Regression
5. Implementation of Multiple Linear Regression for House Price Prediction using sklearn
6. Implementation of Decision tree using sklearn and its parameter tuning
7. Implementation of KNN using sklearn
8. Implementation of Logistic Regression using sklearn
9. Implementation of K-Means Clustering
10. Performance analysis of Classification Algorithms on a specific dataset (Mini Project)

TEXT BOOKS:

1. Machine Learning – Tom M. Mitchell, - MGH.

REFERENCE BOOKS:

1. Machine Learning: An Algorithmic Perspective, Stephen Marshland, Taylor & Francis.

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DATA VISUALIZATION - POWER BI

B.Tech. II Year II Sem.

L	T	P	C
0	0	2	1

Course Outcomes: At the end of the course a student should be able to

- Understand How to import data into Tableau.
- Understand Tableau concepts of Dimensions and Measures.
- Develop Programs and understand how to map Visual Layouts and Graphical Properties.
- Create a Dashboard that links multiple visualizations.
- Use graphical user interfaces to create Frames for providing solutions to real world problems.

Lab Problems:

1. Understanding Data, What is data, where to find data, Foundations for building Data Visualizations, Creating Your First visualization?
2. Getting started with Tableau Software using Data file formats, connecting your Data to Tableau, creating basic charts(line, bar charts, Tree maps),Using the Show me panel.
3. Tableau Calculations, Overview of SUM, AVR, and Aggregate features, Creating custom calculations and fields.
4. Applying new data calculations to your visualizations, Formatting Visualizations, Formatting Tools and Menus, Formatting specific parts of the view.
5. Editing and Formatting Axes, Manipulating Data in Tableau data, Pivoting Tableau data.
6. Structuring your data, Sorting and filtering Tableau data, Pivoting Tableau data.
7. Advanced Visualization Tools: Using Filters, Using the Detail panel, using the Size panels, customizing filters, Using and Customizing tooltips, Formatting your data with colors.
8. Creating Dashboards & Storytelling, creating your first dashboard and Story, Design for different displays, adding interactivity to your Dashboard, Distributing & Publishing your Visualization.
9. Tableau file types, publishing to Tableau Online, Sharing your visualizations, printing, and Exporting.
10. Creating custom charts, cyclical data and circular area charts, Dual Axis charts.

REFERENCES:

1. Microsoft Power BI cookbook, Brett Powell, 2nd edition.
2. R Programming for Data Science by Roger D. Peng (References)
3. The Art of R Programming by Norman Matloff Cengage Learning India.

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INDIAN KNOWLEDGE SYSTEM

B.Tech. II Year II Sem.

L	T	P	C
1	0	0	1

Bharat is considered one of the oldest civilizations of the world. Some of the archaeological evidences proved the existence of Indus Valley Civilization in 7000 B.C. Bhartiya traditions, culture, cultural activities, rituals, sacraments, painting, art of dancing, art of singing etc. is being practised till the modern times without knowing scientific approaches behind that. Eternity of Indian knowledge system proved itself that not only many rituals but also many traditions, many streams of knowledge like astrology, mathematics, physics, chemistry, biology, language studies, yoga and meditation had been following from the starting till now with some changes, in the form of traditions.

This course is for undergraduate students to inculcate Indian values. It will promote advance study and inter disciplinary research on all aspects of the Indian knowledge system.

Course Outcomes: Students will be able to:

1. Understand nature, scope and related fields of Indian knowledge system.
2. Demonstrate the scientific literature available in ancient Indian traditions
3. Understanding the application of Bharatiya Jnana Parampara
4. Understand Indian approach towards Wellbeing
5. Appreciate vast contribution of ancient Indian researchers, engineers, scientists and architects to the modern world

Unit 1: Introduction to Indian Knowledge Systems

Meaning, Nature, Scope and Salient Aspects of Bharatiya Jnana Parampara - Introduction to Vedas, Upanishads, Vidya, Kala, Jnana, Shastra - Practices and Continuity of Tradition

Unit 2: Overview of History of Indian Education and Scientific Literature

Gurukul System - Role of Sanskrit in Natural Language Processing - Scientific Literature - Vedic Literature - Available Scientific Treatises - Interlinkings

Unit 3: Introduction to Scientific Theories from Pure Sciences from Ancient Indian Knowledge Systems

Overview of theories from available ancient Indian Literature about Physics, Chemistry and Mathematics - Interlinkings and applications

Unit 4: Introduction to Ancient Indian Wellness Systems

Concept of Wellness – Yoga System - Ayurveda System - Ancient Indian Aesthetics

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Unit 5: Development of Engineering, Science, Technology & Fine Arts in India
Various Industries - Silk, Cotton and Ship Building - Evolution of Indian Fine Arts – Cave and Temple Architecture, Vastu - Vidya, Sculpture, Forts and Stepwells, Observatories and Paintings - Music and Natyakala - Cultural Traditions & Folk Arts

❖ **Pedagogy for Teachers: Apart from Class Room Instruction, the following Methods are Suggested.**

1. Project based activities and learning.
2. Presentation and case studies.
3. Film screening and book reviews.
4. Visit to historical places, archives centre, research centre or library nearby.

Note: *Activities mentioned above are only suggestive. Teacher-educators should encourage students to be innovative.*

Suggested Readings:

1. B. Mahadevan, Bhat Vinayak and Nagendra Pavan R.N., (2022) '*Introduction to Indian Knowledge Systems: Concepts and Applications*' PHI learning PVT, New Delhi ISBN [9789391818203]
2. Dharmapal (1971) '*Indian Science and Technology in the Eighteenth Century*'. Other India Press, Goa.
3. Kapil Kapoor, Singh Avdhesh Kumar, (2005) '*Indian Knowledge Systems*' D.K. Printworld (P) Ltd. ISBN 10: 8124603367 / ISBN 13: 9788124603369
4. Chakradeo, Ujwala, Temples of Bharat, Aayu Publications, New Delhi, 2024.
5. D.N. Bose, S.N. Sen and B. V. Subbarayappa, *A Concise History of Science in India*, Indian National Science Academy, New Delhi, 2009.
6. Datta B. and A. N. Singh, *History of Hindu Mathematics: Parts I and II*, Asia Publishing House, Bombay, 1962.
7. Kapoor, K. (2021), *Indian Knowledge System: Nature, Philosophy, Character in Indian Knowledge System*, vol. 1, Pub. Indian Institute of Advanced Studies, Shimla
8. Mahadevan, B., Bhat, V.R., Pavana, N. (2022), Philosophical Systems, in Introduction to Indian Knowledge System, Pub. PHI Learning, New Delhi.
9. Mahadevan, B., Bhat, V.R., Pavana, N. (2022), Knowledge: Framework and Classification, in Introduction to Indian Knowledge System, Pub. PHI Learning, New Delhi.

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Video Resources:

1. Introductory lectures by Prof. Gauri Mahulikar
2. Introductory lectures by Prof. Kapil Kapoor

Websites:

- https://iksin dia.org/index.php
- Official Website of IKS- Indian Knowledge System
- https://www.youtube.com/watch?v=uKcf-hSlcUE
- Address by Prof Kapil Kapoor | Indian Institute of Advanced Study (FDP 2021)
- https://www.youtube.com/watch?v=MDJTXNiH2_A
- Mukul Kanitkar on Bharatiya Knowledge System
- https://www.youtube.com/watch?v=uARMhv97pjk
- https://www.youtube.com/watch?v=oTwgf56GbsA
- Scientific History of India | Mukul Kanitkar Lecture in DTU
- https://youtu.be/gNJNmPJqXJc?si=WFBbuUT65mLZzpOW
- Ancient India's Scientific Achievements & Contribution in Mathematics, Astronomy, Science & Medicine

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