Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Bachelor of Technology

in

Electronics and Computer Science

Final Year Scheme & Syllabus

(R 2022)

(As per AICTE guidelines, with effect from the Academic Year 2025-26)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Therefore, autonomy for Vidyalankar Institute of Technology is not merely a transition from pre-cooked syllabi to self-designed curriculum. The autonomous curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability and problem-solving approach which leads to improving competency level of learners with diverse strengths. In line with this, the curriculum framework designed is **Choice Based Credit and Grading System (CBCGS)**. The number of credits for each category of courses learnt by learners, internships and projects is finalized considering the scope of study and the ability that a learner should gain through the programme. The overall credits and approach of curriculum proposed is in line with AICTE model curriculum.

The curriculum comprises courses from various categories like basic sciences, humanities and social sciences, engineering sciences, general education and branch specific courses including professional electives and open electives. The curriculum has core courses of branch of engineering positioned and sequenced to achieve sequential and integral learning of the entire breadth of the specific branch. These courses are completed by the third year of the engineering programme that enables learners to prepare for higher education during their final year. Professional elective courses, that begin from third year of programme, offer flexibility and diversity to learners to choose specialization from a basket of recent developments in their field of technology. The selection of unique professional elective courses based on industrial requirements and organizing them into tracks is a salient feature of this curricula ensuring employability. Open Elective courses cover multi-disciplinary, special skill development, project management and similar knowledge that make learners capable of working in an industrial environment.

For holistic development of learners, apart from technical courses, Humanities and Social Science courses develop the required soft-skills and attitude amongst learners. Our curriculum also introduces Social Service Internship and Internship with institutes abroad along with courses like Design Thinking, Wellness – Body, Mind & Spirit, Indian Traditional Knowledge system under General Education category. These general education courses aim to create balance in brain hemispheres and hence improve learners' clarity in thoughts and responses.

Additionally, curriculum provides add-on Honours/Minor degree that involves field/ domain study. Learners can avail themselves of this degree by completing the requirement of additional 18 credits.

Thus, the academic plan of VIT envisages a shift from summative to formative and competency-based learning system which will enhance learner's ability towards higher education, employability and entrepreneurship.

Chairperson, Board of Studies
Department of Electronics and Computer Science
Vidyalankar Institute of Technology

Chairperson, Academic Council
Vidyalankar Institute of Technology

Final Year B. Tech. Electronics and Computer Science **Semester: VII**
Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
Code	Name			ISA	MSE	ESE	
ECXX	Professional Elective-4	As Per Course	3	As Per Course			
ECXX	Professional Elective-5	As Per Course	3	As Per Course			
ECXX	Professional Elective-6	As Per Course	3	As Per Course			
OEXX*	Any two from the offered Open Elective Courses	Theory	3	20	30	50	100
OEXX*		Theory	3	20	30	50	100
EC47	Project-1 (Synopsis)	Theory	3	50	-	50	100
Total			**18**				
Course credits completed during the previous inter semester break will appear in this semester's marksheet							
EC46	Industry Internship	Practical	5	75	-	75	150

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination
*Selection is based on subset of OE courses offered by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Professional Elective - 4 Courses (ECXX)

Specialization Track Name#	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	EC33T	Data Analytics & Visualization	Theory	2	15	20	40	075
	EC33P	Data Analytics & Visualization Lab	Practical	1	25	-	25	050
Data Science (DA)	EC34T	Big Data Analytics	Theory	2	15	20	40	075
	EC34P	Big Data Analytics	Practical	1	25	-	25	050

		Lab						
Internet of Things (IoT)	EC35T	IoT and Edge Computing	Theory	2	15	20	40	075
	EC35P	IoT and Edge Computing	Practical	1	25	-	25	050
Very Large-Scale Integration (VLSI)	EC36T	ASIC and Verification	Theory	2	15	20	40	075
	EC36P	ASIC and Verification Lab	Practical	1	25	-	25	050

#For details of Specialization Certificate, refer Appendix-A

Professional Elective - 5 Courses (ECXX)

Specialization Track Name#	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	EC37T	Deep Learning	Theory	2	15	20	40	075
	EC37P	Deep Learning Lab	Practical	1	25	-	25	050
Data Science (DS)	EC38T	Recommendation Systems	Theory	2	15	20	40	075
	EC38P	Recommendation Systems Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	EC39T	IoT Security and Trust	Theory	2	15	20	40	075
	EC39P	IoT Security and Trust Lab	Practical	1	25	-	25	050
Very Large-Scale Integration (VLSI)	EC40T	System on Chip	Theory	2	15	20	40	075
	EC40P	System on Chip Lab	Practical	1	25	-	25	050

#For details of Specialization Certificate, refer Appendix-A

Professional Elective - 6 Courses (ECXX)

Specialization Track Name[#]	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Artificial Intelligence and Machine Learning (AIML)	EC41T	Natural language processing	Theory	2	15	20	40	075
	EC41P	Natural language processing Lab	Practical	1	25	-	25	050
Data Science (Ds)	EC42T	Text, Web & Social Media Analytics	Theory	2	15	20	40	075
	EC42P	Text, Web & social media Analytics Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	EC43T	Industrial IOT	Theory	2	15	20	40	075
	EC43P	Industrial IOT Lab	Practical	1	25	-	25	050
Very Large-Scale Integration (VLSI)	EC44T	Mixed Signal VLSI	Theory	2	15	20	40	075
	EC44P	Mixed Signal VLSI Lab	Practical	1	25	-	25	050

[#]For details of Specialization Certificate, refer Appendix-A

Open Elective Courses (OEXX)

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
Code	Name			ISA	MSE	ESE	
OE21	Cyber Law	Theory	3	20	30	50	100
OE22	Project Management	Theory	3	20	30	50	100
OE23	Product Lifecycle Management	Theory	3	20	30	50	100
OE24	Sustainability Management	Theory	3	20	30	50	100
OE25	Operation Research	Theory	3	20	30	50	100
OE26	IPR and Patenting	Theory	3	20	30	50	100
OE27	Research Methodology	Theory	3	20	30	50	100
OE28	Renewable Energy Management	Theory	3	20	30	50	100
OE29	Energy Audit and Management	Theory	3	20	30	50	100
OE30	Bioinformatics	Theory	3	20	30	50	100
OE31	Nanotechnology	Theory	3	20	30	50	100

Final Year B. Tech. Electronics and Computer Science **Semester: VIII**
Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
Code	Name			ISA	MSE	ESE	
OEXX*	Any three from the offered Open Elective courses	Theory	3	20	30	50	100
OEXX*		Theory	3	20	30	50	100
OEXX*		Theory	3	20	30	50	100
EC48	Project 2 – (Final)	Theory + Practical	6	100	-	75	175
Total			**15**				

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination
*Selection is based on subset of OE courses offered by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Open Elective Courses (OEXX)

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
Code	Name			ISA	MSE	ESE	
OE21	Cyber Law	Theory	3	20	30	50	100
OE22	Project Management	Theory	3	20	30	50	100
OE23	Product Lifecycle Management	Theory	3	20	30	50	100
OE24	Sustainability Management	Theory	3	20	30	50	100
OE25	Operation Research	Theory	3	20	30	50	100
OE26	IPR and Patenting	Theory	3	20	30	50	100
OE27	Research Methodology	Theory	3	20	30	50	100
OE28	Renewable Energy Management	Theory	3	20	30	50	100
OE29	Energy Audit and Management	Theory	3	20	30	50	100
OE30	Bioinformatics	Theory	3	20	30	50	100
OE31	Nanotechnology	Theory	3	20	30	50	100

Detailed Syllabus of Final Year (Semester – VII & VIII)

Course Name: Data Analytics & Visualization

Course Code: EC33T

Category: Professional Elective Course

Preamble:

Data Analytics and Visualization form the backbone of modern data-driven decision-making. This course equips students with skills to process, analyze, and visualize complex datasets using cutting-edge tools and techniques. Applications span business intelligence, healthcare, finance, and social media, emphasizing ethical data practices and real-world problem-solving.

Pre-requisites:

1. Basic Programming (Python/R)
2. Introductory Statistics
3. Fundamentals of Machine Learning

Course Objectives:

After completing this course, students will be able to:

Understand core concepts of data analytics and visualization.
Apply tools like Python (Pandas, Matplotlib), R (tidyverse), Tableau, and Power BI.
Design advanced visualizations (geospatial, interactive dashboards).
Analyze big data using Hadoop/Spark and NoSQL databases.
Evaluate statistical and ML models for actionable insights.

Course Outcomes:

Learner will be able to :
CO1: Explain data analytics lifecycle and visualization principles.
CO2: Perform EDA and data preprocessing using Python/R/SQL.
CO3: Develop interactive dashboards with Tableau/Power BI.
CO4: Implement big data analytics using Hadoop/Spark.
CO5: Create end-to-end projects with storytelling techniques.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Fundamentals	1. **Introduction to Data Analytics**: Definition, significance in modern industries, and real-world applications across domains like business, healthcare, and social sciences. 2. **Types of Data Analytics**: 1. Descriptive Analytics: Summarizing historical data (e.g., sales trends, customer demographics). 2. Predictive Analytics: Forecasting future outcomes using statistical models and ML (e.g., demand prediction, risk assessment). 3. **Ethics and Privacy**: Data governance, GDPR compliance, bias mitigation, and ethical implications of data misuse.	4
2	Big Data Analytics	• **Big Data Fundamentals**: o 4 Vs: Volume (scalability), Velocity (streaming data), Variety (structured/unstructured), Veracity (data quality). • **Tools and Frameworks**: o Hadoop/Spark: Distributed processing (MapReduce, Spark SQL). o NoSQL Databases: MongoDB (document-based), Cassandra (column-oriented). • **Real-Time Visualization**: o D3.js: Custom interactive visualizations for web applications. o Plotly Dash: Building real-time dashboards with Python.	6
3	Advanced Visualization	• **Chart Types**: o Heatmaps: Correlation matrices, user behavior analysis.	6

		○ Geospatial: Folium (Python) for COVID-19 hotspot mapping; Leaflet (R) for GIS applications. • **Interactive Dashboards**: ○ Tableau: Parameters, actions, and storytelling features. ○ Power BI: DAX queries, embedded analytics	
4	Statistical Decision Making	• **Hypothesis Testing**: ○ t-tests/ANOVA: Comparing groups (e.g., A/B testing for marketing). ○ Chi-square: Categorical data analysis (e.g., survey responses). • **Regression Analysis**: ○ Linear Regression: Predicting housing prices. ○ Logistic Regression: Customer churn prediction. • **Time Series**: ARIMA models for stock price forecasting.	6
5	ML Visualization	• **Model Evaluation**: ○ ROC Curves: Classifier performance thresholds. ○ SHAP Values: Interpreting feature importance in ML models. • **Dimensionality Reduction**: ○ PCA/t-SNE: Visualizing high-dimensional clusters (e.g., customer segmentation).	6
6	Case Studies	• **Case Studies**: ○ Healthcare: Patient readmission risk dashboards. ○ Finance: Fraud detection visualizations. • **AR/VR Trends**: Immersive data exploration (e.g., virtual stock market floors). .	6
Total			**30**

Textbooks:

- Python for Data Analysis – Wes McKinney
- R for Data Science – Hadley Wickham
- Storytelling with Data – Cole Nussbaumer Knaflic

Reference Books:

- Data Science for Business – Provost & Fawcett
- Interactive Data Visualization – Scott Murray

Course Name: Data Analytics & Visualization Lab

Course Code: EC33T

Category: Professional Elective Course

Preamble:

This hands-on lab course develops practical skills in data processing, analysis, and visualization using industry-standard tools. Through experimental learning, students will work with real datasets to implement data pipelines, create interactive visualizations, and build dashboards. The lab focuses on applied techniques for data cleaning, exploratory analysis, and visual storytelling using Python/R, Tableau, and Power BI in a project-based environment.

Pre-requisites:

- Programming Fundamentals (Python/R)
- Basic Statistics
- Introduction to Data Structures

Course Objectives:

After completing this lab course, students will be able to:

- Implement complete data processing pipelines from raw data to insights
- Design and develop interactive visualizations and dashboards
- Apply analytical techniques to solve real-world problems through hands-on projects

Course Outcomes:

Upon completion, learners will be able to:

CO1: Execute end-to-end data analysis workflows (cleaning, transformation, visualization)

CO2: Build effective data visualizations and dashboards using modern tools

CO3: Demonstrate analytical solutions through practical case studies and projects

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Lab Experiments:

- **Data Cleaning & Preprocessing** – Handle missing values, outliers, and feature engineering using Pandas (Python) or dplyr (R).
- **Exploratory Data Analysis (EDA)** – Generate statistical summaries, correlation matrices, and distribution plots.
- **Statistical Testing** – Perform t-tests, ANOVA, and regression analysis with SciPy (Python) or stats (R).
- **Time Series Visualization** – Plot trends, seasonality, and forecasts using Matplotlib/Seaborn or ggplot2.
- **Geospatial Mapping** – Create choropleth and heatmaps with Folium (Python) or Leaflet (R).
- **Interactive Dashboards** – Build real-time dashboards in Tableau, Power BI, or Plotly Dash.
- **ML Model Visualization** – Plot ROC curves, SHAP values, and decision boundaries.
- **Capstone Project** – End-to-end data pipeline from cleaning to interactive visualization

Tools/Platforms:

- Python (Pandas, Matplotlib, Seaborn)
- R (tidyverse, ggplot2)
- Tableau/Power BI
- Jupyter Notebook/RStudio

Text Books:

- Python for Data Analysis - Wes McKinney
- R for Data Science - Hadley Wickham
- Storytelling with Data - Cole Nussbaumer Knaflic
- Big Data: Principles and Best Practices - Marcus Schroeck

Reference Books:

1. Data Science for Business - Foster Provost
2. Interactive Data Visualization - Scott Murray
3. The Visual Display of Quantitative Information - Edward Tufte

Course Name: Big Data Analytics

Course Code: EC34T

Category: Professional Elective Course

Preamble:
Big Data Analytics focuses on processing and analyzing massive datasets to extract valuable insights for decision-making. This course covers fundamental concepts, big data frameworks like Hadoop and Spark, machine learning applications, and real-time analytics. Students will gain hands-on experience with industry tools, enabling them to design and implement efficient big data solutions for real-world challenges.

Pre-requisite:
- Data Structure and Database Management System
- Data Mining

Course Objectives:
1. To introduce the concept of Big Data and differentiate traditional data processing approaches from big data approaches using Hadoop.
2. To enable students to understand and implement big data processing using Hadoop HDFS, MapReduce, and MongoDB.
3. To familiarize students with advanced analytics through stream data processing and Apache Spark.

Course Outcomes:
After successful completion of the course students will be able to:
CO1: Explain the characteristics and business implications of Big Data and identify use cases suitable for big data solutions.
CO2: Apply Hadoop HDFS and MapReduce programming model for processing large-scale datasets efficiently.
CO3: Demonstrate proficiency in using MongoDB for document-based data storage and querying.
CO4: Analyze and implement data stream mining techniques like sampling, filtering, and counting using algorithms such as Bloom Filters and DGIM.
CO5: Utilize Apache Spark for scalable data analytics including text, web content, and link analysis.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Unit No.	Contents	Hrs.
1		**Module 1: Introduction to Big Data and Hadoop**	02
	1.1	Introduction to Big Data: Characteristics of Big Data (Volume, Velocity, Variety, Veracity, Value) , Types of Big Data.	
	1.2	Traditional vs. Big Data Business Approach	
	1.3	**Case Study of Big Data Solutions**	
	1.4	**Hadoop Overview:** Concept of Hadoop, Core Hadoop Components, Hadoop Ecosystem	
2		**Hadoop HDFS and MapReduce**	08
	2.1	**Distributed File Systems** Physical Organization of Compute Nodes, Large-Scale File-System Organization	
	2.2	**MapReduce Programming Model** Map Tasks, Grouping by Key, Reduce Tasks, Combiners, Execution Process & Handling Node Failures	
	2.3	**Algorithms Using MapReduce** Matrix-Vector Multiplication, Relational Algebra Operations (Selection, Projection, Union, Intersection, Difference)	
	.24	**Hadoop Limitations**	
3		**Introduction to MongoDB**	06
	3.1	**Introduction to MongoDB**: What is MongoDB? Features and Advantages of MongoDB, Comparison with Relational Databases	
	3.2	Terms used in RDBMS and MongoDB	
	3.3	Data Types in MongoDB: BSON (Binary JSON) Overview, Supported Data Types: String, Number, Boolean, Array, Object, Date, etc., Handling Null and Missing Values	
	3.4	MongoDB Query Language: CRUD Operations (Create, Read, Update, Delete), Querying and Filtering Documents, Updating Documents, Deleting Documents	
4		**Mining Data Streams**	08
	4.1	**The Stream Data Model** Data-Stream-Management System, Examples of Stream Sources, Stream Queries & Issues in Stream Processing	
	4.2	**Sampling Techniques in Data Streams**	
	4.3	**Filtering Streams** Bloom Filter with Analysis	
	4.4	**Counting Distinct Elements in a Stream** Count Problem, Flajolet-Martin Algorithm, Combining Estimates & Space Requirements	
	4.5	**Counting Ones in a Window** Cost of Exact Counting, Datar-Gionis-Indyk-Motwani (DGIM) Algorithm, Query Answering in DGIM, Decaying Windows	
5		**Spark and Big Data Analytics:**	06
	5.1	**Spark, Introduction to Data Analysis with Spark.**	
	5.2	**Text, Web Content and Link Analytics:** Introduction, Text Mining, Web Mining, Web Content and Web Usage Analytics, Page Rank, Structure of Web and Analyzing a Web Graph.	
	5.3		
		Total	**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Big data and Analytics 2. Rajkamal and Preeti Saxena, "Big Data Analytics, Introduction to Hadoop, Spark and Machine Learning", McGraw Hill Publication, 2019	Seema Acharya and Subhashini Chellappan	Wiley India Publishers	2nd Edition, 2019	1, 2, 3, 4
2	Big Data Analytics, Introduction to Hadoop, Spark and Machine Learning	Rajkamal and Preeti Saxena	McGraw Hill Publication,	2019	5
3	Hadoop in Practice	Alex Holmes	Manning Press, Dreamtech Press.	--	1,2
4	Mining of Massive Datasets	Cre Anand Rajaraman and Jeff Ullman	Cambridge University Press	5th	4

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics	Bill Franks	Wiley	--	1,4,5
2	Hadoop in Action	Chuck Lam	Dreamtech Press	--	2
3	Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners	Jared Dean	Wiley India Private Limited,	2014	3,4
4	Data Mining: Concepts and Techniques	Jiawei Han, Micheline Kamber	Morgan Kaufmann Publishers	3rd Edition, 2010	3,4

5	Data Mining and Knowledge Discovery Handbook	Lior Rokach, Oded Maimon	Springer	2nd Edition, 2010	2, 3, 4
6	The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data	Ronen Feldman, James Sanger	Cambridge University Press	2006	5
7	Learning and Soft Computing	Vojislav Kecman	MIT Press	2010	5
8	Data Science and Big Data Analytics	EMC Education Services	Wiley		1, 2, 3

Course Name: Big Data Analytics Lab

Course Code: EC34P

Category: Professional Elective Course

Preamble:
Big Data Analytics focuses on processing and analyzing massive datasets to extract valuable insights for decision-making. This course covers fundamental concepts, big data frameworks like Hadoop and Spark, machine learning applications, and real-time analytics. Students will gain hands-on experience with industry tools, enabling them to design and implement efficient big data solutions for real-world challenges.

Pre-requisite:
- Data Structure and Database Management System
- Data Mining
- C/ python/Java programming

Course Objectives:

4. Introduce students to the Hadoop ecosystem and help them understand distributed file storage and processing concepts.
5. Enable students to write and execute basic to advanced MapReduce programs for solving real-world data problems.
6. Familiarize students with NoSQL databases, particularly MongoDB, and perform fundamental data operations using document-based storage.
7. Develop competency in stream processing techniques and real-time analytics using algorithms and Apache Spark.

Course Outcomes:
After successful completion of the course students will be able to:
CO1: Demonstrate the use of Hadoop Distributed File System (HDFS) and perform basic operations in a Hadoop ecosystem.
CO2: Design and implement MapReduce programs for data processing tasks such as word count, matrix operations, and real-time analytics.
CO3: Apply NoSQL concepts by performing CRUD operations using MongoDB and analyzing document-based data.
CO4: Simulate data streams and utilize stream processing algorithms and Apache Spark for big data analytics.
.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Hadoop HDFS Practical: -HDFS Basics, Hadoop Ecosystem Tools Overview. -Installing Hadoop. -Copying File to Hadoop. -Copy from Hadoop File system and deleting file. -Moving and displaying files in HDFS. -Programming exercises on Hadoop	Hadoop architecture, core components (HDFS, MapReduce), ecosystem overview, HDFS commands, distributed file storage concepts	CO1
2	1	Implement Word Count using MapReduce	MapReduce programming basics – Mapper, Reducer, Combiners	CO1
3	3	Matrix-Vector multiplication using MapReduce	Parallel data processing using MapReduce model	CO2
4	3	Perform Selection, Projection, Union operations using MapReduce	Relational algebra in distributed systems	CO2
5	2	Develop a Map Reduce program that mines weather data and displays appropriate messages indicating the weather conditions of the day.	MapReduce Programming Model and Text File Parsing and Data Extraction	CO2
6	2	Develop a MapReduce program to find the tags associated with each movie by analyzing movie lens data.	MapReduce Programming Model and Text File Parsing and Data Extraction	CO2
7	3	Install MongoDB and perform CRUD operations	MongoDB shell, inserting, querying, updating, and deleting documents	CO2
8	4	Simulate a stream of sensor data and perform basic stream queries	Streaming concepts, real-time vs. batch processing	CO3
9	4	Estimate count of distinct elements using Flajolet-Martin Algorithm	Approximate counting, hash-based algorithms	CO4
10	5	Install Apache Spark and perform basic data analysis using PySpark	RDDs, DataFrames, Spark transformations and actions	CO4

Course Name: ASIC and Verification

Course Code: ET36T

Category: Professional Elective Course

Preamble:

This course introduces students to different methods used for Verification of digital circuits using System VERILOG. This course gives guidelines for building Test-bench helps to understand how and why to use classes, randomization, and functional coverages.

Pre-requisites:

1. Electronics Devices and Circuits.
2. Logic circuits.
3. Digital VLSI.
4. Digital system design with VERILOG & FPGA.

Course Objectives:

The aim of this course is,

1. To highlight the System Verilog Verification Language Construct.
2. A profound understanding of creating test-bench for verification of digital circuits.
3. Use of classes, randomization, and functional coverages.

Course Outcomes:

CO1: Students will be able to understand. Verification techniques to serve as a foundation for learning and using the System Verilog language.
CO2: Students will be able to illustrate various data types such as arrays, structures, and enumerated types.
CO3: Students will be able to Design the various Test-benches for verification.
CO4: Students will be able to understand the concept of randomization, threads and Inter process communication.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Verification Guidelines	1.1 Verification Process, Verification Methodology, Basic Test-Benches functionality. Test bench components, Layered testbench.	4
2	Basics of System Verilog	2.1 Introduction to System Verilog, Data types, Built in data types, Fixed size arrays, Dynamic arrays, queues, and associative arrays. Array methods. 2.2 Types, creating new types, enumerated types, Type conversion, Static and Dynamic cast.	8
3	System Verilog control flow.	3.1 Loops: while/do while, for each loop, for loop, forever loop. Case statements. 3.2 Functions, Tasks, Blocking and Non-Blocking. Randomization, System Verilog interfaces.	5
4	System Verilog object-oriented programming.	4.1Introduction, Class, creating new object, object declaration, class methods. Defining methods outside the class. Static and Global variables. Class inside class. Dynamic objects, copying objects.	8
5	System Verilog threads and communication	5.1 fork_join and begin_ end. Semaphores and events. Mail-boxes etc.	5
Total			**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	System Verilog for Verification.	Chris spear and Greg Tumbush.	Springer.	3rd Edition.	All.
2	System Verilog Assertions and Functional coverage.	Ashok Mehta.	Springer.	3rd Edition.	1,2,3,4

Reference Books:

1. System Verilog for design by Stuart Sutherland, Simon David Mann, Peter flake.2nd edition. Springer Publications.

Course Name: ASIC and Verification. Lab

Course Code: ET36P

Category: Professional Elective Course

Preamble:
This course introduces students to different methods used for Verification of digital circuits using System VERILOG. This course gives guidelines for building Test-bench helps to understand how and why to use classes, randomization, and functional coverages.

Pre-requisites:

1. Electronics Devices and Circuits.
2. Logic circuits.
3. Digital VLSI.
4. Digital system design with VERILOG & FPGA.

Course Objectives:

The aim of this course is,
1. To highlight the System Verilog Verification Language Construct.
2. A profound understanding of creating test-bench for verification of digital circuits.
3. Use of classes, randomization, and functional coverages.

Course Outcomes:

CO1: Students will be able to understand basics of System Verilog, including data types, operators, and language constructs.
CO2: Students will be able to create test benches to verify ASIC designs using System Verilog.
CO3: Students will be able to Design assertions and constraints to ensure ASIC designs and meet required specifications.
CO4: Students will be able to understand the various stages of ASIC design, including RTL design, synthesis, and verification.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	25	-	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the

commencement of the semester.

Suggested List of Practical's:

1. Handling variables, types, and basic operations in System Verilog.
2. Array declaration, array handling in System Verilog.
3. Exercise using procedural statements in System Verilog.
4. Exercise using task and functions in System Verilog.
5. Design and Implementation of various combinational circuits using System Verilog.
6. Design and Implementation of various sequential circuits using System Verilog.
7. Design and Implementation FSM using System Verilog.
8. Developing test benches for basic digital circuits using system Verilog.
9. Write assertions to verify digital circuits using system Verilog.

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	System Verilog for Verification.	Chris spear and Greg Tumbush.	Springer.	3rd Edition.	All.
2	System Verilog Assertions and Functional coverage.	Ashok Mehta.	Springer.	3rd Edition.	1,2,3,4

Reference Books:

1. System Verilog for design by Stuart Sutherland, Simon David Mann, Peter flake.2nd edition. Springer Publications.

.

Course Name: Deep Learning

Course Code: EC37T

Category: Professional Elective Course

Preamble:

This course provides an in-depth study of deep learning architectures, algorithms, and applications. It covers neural networks, backpropagation, CNNs, RNNs, GANs, and transformers, with hands-on implementation using TensorFlow and PyTorch. Through practical exercises, case studies, and projects, students will develop expertise in designing, training, and optimizing deep neural networks for research and industry applications.

Pre-requisites:

- Basic mathematics and Statistical concepts
- Linear algebra
- Machine Learning
- Soft Computing

Course Objectives:
After completing this course, students will be able to:

- To learn the fundamentals of Neural Network.
- To gain an in-depth understanding of training Deep Neural Networks.
- To acquire knowledge of advanced concepts of Convolution Neural Networks,
- Autoencoders and Recurrent Neural Networks.
- Students should be familiar with the recent trends in Deep Learning.

Course Outcomes:
Learner will be able to :
CO1: Gain basic knowledge of Neural Networks.
CO2: Acquire in depth understanding of training Deep Neural Networks.
CO3: Design appropriate DNN model for supervised, unsupervised and sequence learning applications.
CO4: Gain familiarity with recent trends and applications of Deep Learning.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based

on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Fundamentals of Neural Network	• Review of Neural Networks (MLPs, Backpropagation, Activation Functions) • Optimizers (SGD, Momentum Based GD, , AdaGrad, Nesterov Adam, RMSProp) • Loss Functions and Regularization Techniques (L1/L2, Dropout, BatchNorm)	8
2	Convolutional Neural Networks (CNNs)	• Basics of CNNs (Convolution, Pooling, Padding, Stride) • Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture • Advanced Architectures: ResNet, DenseNet, EfficientNet • Transfer Learning and Fine-tuning CNNs • Applications: Image Classification, Object Detection	6
3	Recurrent Neural Networks (RNNs) and Sequence Modeling	• Introduction to RNNs, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, • Long Short-Term Memory (LSTM) : Selective Read, Selective write, Selective Forget, and Gated Recurrent Units (GRUs)	6
4	Generative Deep Learning	• Autoencoders (AE, Variational Autoencoders - VAE) • Generative Adversarial Networks (GANs) and their Variants (DCGAN, CycleGAN, StyleGAN) Diffusion Models for Image Generation • Applications: Image Generation, DeepFake	6
5	Deep Reinforcement Learning	• Basics of Reinforcement Learning Q-Learning) • Deep Q Networks (DQN) • Applications: Robotics, Game AI, Financial Forecasting	4
Total			**30**

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville. —Deep Learning||, MIT Press Ltd, 2016
2. Li Deng and Dong Yu, —Deep Learning Methods and Applications||, Publishers Inc.
3. Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4. JM Zurada —Introduction to Artificial Neural Systems||, Jaico Publishing House
5. M. J. Kochenderfer, Tim A. Wheeler. —Algorithms for Optimization||, MIt Press.

Reference Books:

1. Buduma, N. and Locascio, N.,"Fundamentals of deep learning: Designing next-generation
2. machine intelligence algorithms" 2017. O'Reilly Media, Inc.".
3. François Chollet."Deep learning with Python"(Vol. 361). 2018 New York: Manning.
4. Douwe Osinga. "Deep Learning Cookbook" O'REILLY, SPD Publishers, Delhi.
5. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
6. S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India

Course Name: Deep Learning Lab

Course Code: EC37P

Category: Professional Elective Course

Preamble:

The Deep Learning Lab provides a hands-on environment for students to implement and experiment with deep learning concepts, architectures, and frameworks. This lab complements theoretical knowledge by enabling students to design, train, and optimize neural networks using tools like TensorFlow and PyTorch.

Pre-requisites:

- Programming Fundamentals (Python/R)
- Engineering Mathematics

Course Objectives:

After completing this lab course, students will be able to:

- To implement basic neural network models for simulating logic gates.
- To implement various training algorithms for feedforward neural networks.
- To design deep learning models for supervised, unsupervised and sequence learning.

Course Outcomes:

Upon completion, learners will be able to:

CO1: Implement basic neural network models to learn logic functions.

CO2: Design and train feedforward neural networks using various learning algorithms.

CO3: Build and train deep learning models such as Autoencoders, CNNs, RNN, LSTM etc.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Lab Experiments:

- Implement logistic regression classification with (a) gradient descent and (b) stochastic gradient descent method. Plot cost function over iteration.
- Experiment with logistic regression by adding momentum term, and adaptive subgradient method
- Write the code to learn weights of a perceptron for Boolean functions (NOT, OR, AND, NOR, and NAND).
- Implement a feed-forward neural network for solving (a) regression and (b) 2-class
- classification problem. Also experiment with hyper-parameter tuning.
- Train and test a feed-forward neural network for multi-class classification using softmax layer as output.
- Create a 2D and 3D CNN for image classification. Experiment with different depth of network, striding and pooling values.
- Implement (a) RNN for image classification, (b) GRU network and (c) Implement LSTM networks
- Implement an auto-encoder, denoising autoencoders and sparse autoencoders.
- Design a stochastic encoders and decoders.

Tools/Platforms:

- Python (Pandas, Matplotlib, Seaborn)
- R (tidyverse, ggplot2)
- Tableau/Power BI
- Jupyter Notebook/RStudio

Text Books:

- Python for Data Analysis - Wes McKinney
- R for Data Science - Hadley Wickham
- Storytelling with Data - Cole Nussbaumer Knaflic
- Big Data: Principles and Best Practices - Marcus Schroeck

Reference Books:

1. Data Science for Business - Foster Provost
2. Interactive Data Visualization - Scott Murray
3. The Visual Display of Quantitative Information - Edward Tufte

Course Name: Recommendation Systems

Course Code: EC38T

Category: Professional Elective Course

Preamble:
Recommendation Systems have become a crucial part of modern applications, helping users discover relevant products, services, and content. This course covers the fundamental principles, algorithms, and techniques used to build recommendation systems. It provides a deep understanding of collaborative filtering and content-based filtering. Hands-on experience with real-world datasets and case studies ensures a practical learning approach.

Pre-requisite:
- Python Programming
- Machine Learning
- Database
- Data Structures

Course Objectives:
- To introduce the core concepts and techniques used in recommendation systems.
- To explore different recommendation algorithms, including collaborative filtering, content-based filtering, and hybrid approaches.
- To understand how deep learning and AI techniques enhance recommendations.
- To apply recommendation techniques to real-world datasets.
- To evaluate and optimize recommendation models using appropriate metrics.

Course Outcomes:
After successful completion of the course students will be able to:
CO1: Understand the principles and applications of recommendation systems.
CO2: Implement different recommendation techniques and compare their effectiveness.
CO3: Design and develop a recommendation system using machine learning models.
CO4: Evaluate the performance of recommendation systems using standard metrics.
CO5: Apply recommendation techniques to domains such as e-commerce, media, and healthcare.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Recommendation Systems**	04
	1.1	Definition and Types of recommendation systems	
	1.2	Business value of Recommender System A conceptual framework for understanding recommender system	
	1.3	Real World Applications	
	1.4	Challenges in building recommendation systems	
2		**Data for recommendation: Explicit Vs Implicit data collection**	04
	2.1	Scales of measurement	
	2.2	Statistical and machine learning foundations for recommender system	
	2.3	Data preprocessing	
3		**Collaborative Filtering**	06
	3.1	Collaborative filtering approaches: Memory based and model based	
	3.2	Memory based collaborative filtering foundations: Distance and similarity measures User based collaborative filtering	
	3.3	Item based collaborative filtering	
	3.4	Model based collaborative filtering foundations: matrix factorization, UV decomposition, Singular value decomposition Model based collaborative filtering techniques: SVD, SVD++ etc.	
4		**Content based recommender System**	06
	4.1	Feature engineering: Feature extraction, feature selection, dimensionality reduction	
	4.2	Content-based recommended system examples with few supervised machine learning techniques	
5		**Evaluation of recommended systems**	06
	5.1	Online and offline evaluation, metrics such as RMSE, AME, Good Item MAE, Good predicted item MAE,	
	5.2	Precision, Recall, F1 Measure, NDCG, Average Reciprocal Rank	
6		**Case Studies & Applications**	04
	7.1	Overview of other types of recommended systems such as trust based, social network based, and context aware systems	
	7.2	Case Studies (E.g.: Netflix, Flipkart)	
		Total	**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Recommender Systems: An Introduction	Dietmar Jannach, Markus Zanker, Alexander Felfernig, Gerhard Friedrich	Cambridge University Press	1st	1,2,3
2	Recommender Systems Handbook	Francesco Ricci, Lior Rokach, Bracha Shapira, Paul B. Kantor	Springer	2nd	1,2,3,4,5
3	Hands-On Recommendation Systems with Python	Rounak Banik	Packt Publishing	1st	2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Deep Learning for Recommender Systems	Charu Aggarwal	Springer	1st	5,6
2	Practical Recommender Systems	Kim Falk	Manning Publications	1st	3,4,5
3	Recommendation Engines	Michael Schrage	MIT Press	1st	6

Course Name: Recommendation Systems Lab

Course Code: EC38P

Category: Professional Elective Course

Preamble:
The Recommendation Systems Laboratory is designed to provide hands-on experience in implementing and evaluating various recommendation algorithms. Students will work with real-world datasets and apply machine learning, deep learning, and hybrid approaches to build personalized recommendation systems. The course ensures that students gain practical exposure to industry-standard tools and libraries used for recommendation model development.

Pre-requisite:

- Basic knowledge of Python programming
- Understanding of Probability, Statistics, and Linear Algebra
- Familiarity with Machine Learning concepts
- Basic knowledge of Databases and Data Processing

Course Objectives:

1. Provide hands-on experience in implementing different recommendation algorithms.
2. Develop skills in working with real-world datasets for building recommendation models.
3. Learn to evaluate and optimize the performance of recommendation systems.
4. Apply deep learning techniques for recommendation models.
5. Explore industry use cases and ethical considerations in recommendation systems.

Course Outcomes:
After successful completion of the course students will be able to:
CO1: Understand and explore different types of recommendation systems.
CO2: Apply various recommendation algorithms using Python libraries.
CO3: Analyze the performance of recommendation models using evaluation metrics.
CO4: Evaluate and compare different recommendation techniques based on efficiency and accuracy.
CO5: Develop a complete recommendation system for a real-world application.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the

commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Introduction to Recommendation Systems	Overview, Types of Recommendation Systems, Environment Setup (Python, Pandas, NumPy, Scikit-learn)	CO1
2	4	Content-Based Filtering	Feature Engineering, TF-IDF, Cosine Similarity	CO2
3	3	User-Based Collaborative Filtering	Pearson Correlation, k-NN, User Similarity Computation	CO2 CO3
4	3	Item-Based Collaborative Filtering	Item Similarity Computation, k-NN Implementation	CO2 CO3
5	3	Matrix Factorization using SVD	Singular Value Decomposition (SVD), Dimensionality Reduction	CO3 CO4
6	4	Hybrid Recommendation System	Combining Content-Based and Collaborative Filtering	CO3 CO4
7	3,4	Implementing Recommendation Models using Surprise Library	Using the Surprise Library, Implementing SVD, k-NN models	CO2 CO3 CO4
8	2	Machine Learning for Recommendations	Autoencoders, Neural Networks for Recommendations	CO5
9	5	Evaluating Recommendation Systems	Precision, Recall, RMSE, NDCG, Performance Analysis	CO3 CO4
10	6	Project: Building a Movie Recommendation System	Using Movie Lens Dataset, Applying Various Techniques	CO5
11	6	Project: E-commerce Product Recommendation	Implementing Recommendations for E-commerce using Amazon Dataset	CO5

Course Name: System on Chip

Course Code: EC40T

Category: Professional Elective Course

Preamble:

This course provides a comprehensive introduction to the design and architecture of System on Chip (SoC), covering fundamental concepts such as processor architecture, memory design, and interconnect systems. Students will explore trade-offs in performance, power, and area, along with techniques for minimizing delays and costs. The curriculum includes detailed discussions on customization, configuration, and reconfigurable concepts tailored for modern SoC applications. Through a blend of theoretical and practical insights, learners will gain expertise in designing robust and efficient SoC solutions. The course is structured into six modules, totalling 30 hours, to ensure a thorough understanding of each critical component. Ideal for aspiring engineers, this course equips participants with the skills needed to tackle real-world challenges in SoC development.

Pre-requisites:

1. Microprocessors & Microcontrollers
2. Computer Organization & Architecture
3. Digital Electronics
4. VLSI Design (Optional but beneficial)

Course Objectives:

After completing this course, students will be able to:

1. To know the basic concepts of System on Chip
2. To understand SoC design with respect to Processor Architecture, Memory, Interconnect and Trade-offs
3. To be familiar with basics of SoC Customization and Configuration

Course Outcomes:

Learners will be able to:

CO1: Understand overview of SoC System Architecture
CO2: Select Processor for a SoC
CO3: Develop knowledge of memory and interconnect design for SoC
CO4: Apply the knowledge of design tradeoffs for optimized SoC performance
CO5: Describe SoC Customization and Configuration

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to SoC and System Approach	1.1 Overview of System Architecture: Components of a System: Processor, Memory and Interconnects, Basic SoC Model, Hardware and Software: Programmability versus Performance 1.2 Processor Architectures: Functional view approach, Architectural view approach 1.3 Memory and Addressing: Architecture of Memory and Memory for SoC operating Systems 1.4 System Interconnects: Bus based and NoC based interconnect Approach An Approach for SOC Design	7
2	Processor Architecture for SoC	2.1 Processor Selection: Overview and Processor Core Selection 2.2 Basic concepts in Processor Microarchitecture; Basic elements in Instruction Handling: Decoding, Bypassing and Execution unit 2.3 Introduction to Robust Architectures	4
3	Design Trade off and minimizing delays and cost	3.1 Design Tradeoff: Time, Area and Power, reliability and Configurability, 3.2 Buffers: Minimizing Pipeline Delays 3.3 Branches: Reducing Branch Cost	4
4	Memory Design	4.1 Overview: Outline for Memory Design, SoC external Flash Memory And internal memory placement, Size tradeoff 4.2 Scratch pad and Cache Organization: Write Policies, Strategies for Line Replacement at miss time, Multilevel Caches, L1-Icache L1-Dcache 4.3 Memory Address Translation: Translation of Virtual to Real, TLB	6
5	Interconnect Design	5.1 Overview of Interconnect Architectures 5.2 Bus Architectures: Arbitration, Bridge and Bus Structure 5.3 Standard Buses: AMBA and Core Connect Bus	5

6	Customizatio n and Configuration	6.1 Introduction: Estimating Effectiveness of Customization 6.2 Overview of SoC Customization 6.3 Customizing Instruction Processors 6.4 Introduction to Reconfigurable concept	4
Total			**30**

Textbooks:

1. Michael J. Flynn and Wayne Luk, Computer System Design System-on-Chip, Wiley India Pvt. Ltd.

2. Steve Furber, ARM System on Chip Architecture, 2ndEdition, 2000, Addison Wesley Professional

Reference books:

1. Ricardo Ries, Design of System on a Chip: Devices and Components, 1stEdition, 2004, Springer

2. Jason Andrews, Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology), Newnes, BK and CDROM.

3. Prakash Rashinkar, Peter Paterson and Leena Singh L, System on Chip Verification Methodologies and Techniques, 2001, Kluwer Academic Publishers

Course Name: System on Chip Lab

Course Code: EC40L

Category: Professional Elective Course

Preamble:

This hands-on lab course complements the theoretical foundations of SoC design by providing practical exposure to key tools, methodologies, and workflows used in industry and academia. Through 10 structured lab sessions, students will explore processor simulation, memory hierarchy optimization, interconnect design, FPGA prototyping, and verification techniques. The course emphasizes open-source tools (e.g., gem5, QEMU, RISC-V) alongside industry-standard platforms (e.g., Cadence, Synopsys) to bridge the gap between theory and real-world SoC development. By the end of the course, students will be proficient in designing, analyzing, and optimizing SoC components while adhering to power, performance, and area (PPA) constraints.

Pre-requisites:

- Digital Electronics (mandatory).
- Computer Architecture (mandatory).
- FPGA/VLSI basics (recommended).
- Programming (C/Python/Verilog).

Course Objectives:

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

- Simulate and analyze processor architectures using tools like QEMU and gem5.
- Design and evaluate memory subsystems (caches, scratchpads) using trace-driven tools (Dinero IV).
- Model on-chip interconnects (AMBA buses, NoCs) and analyze their performance.
- Prototype SoC components on FPGAs using open-source (Litex) or licensed (Vivado) toolchains.
- Optimize PPA tradeoffs through RTL synthesis and static timing analysis (OpenSTA/Design Compiler).
- Extend processor ISAs (e.g., RISC-V) and verify custom instructions.
- Develop verification testbenches using UVM/SystemC for functional validation.
- Compare open-source and commercial tools for SoC design flows.

Course Outcomes:

Upon completion, learners will be able to:

CO1: Design and simulate processor architectures (RISC-V/ARM) using tools like QEMU/gem5 to analyze performance metrics.
CO2: Optimize memory hierarchies (caches, scratchpads) using trace-driven tools (Dinero IV) and justify design choices.
CO3: Implement on-chip interconnects (AMBA/NoC) and evaluate their latency/throughput in SystemC or BookSim.

CO4: Prototype a minimal SoC (processor + peripherals) on FPGA using open-source (Litex) or licensed (Vivado) toolchains.
CO5: Synthesize RTL designs (Verilog/VHDL) and analyze power-area-delay tradeoffs using OpenSTA/Synopsys tools.
CO6: Verify SoC modules using UVM testbenches and demonstrate functional correctness.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practicals:

Lab Experiments:

1. SoC Design Flow Overview
   Tool: Cadence Innovus (Licensed) / OpenROAD (Open-source)
   Task:
   Explore the end-to-end SoC design flow (RTL to GDSII).
   Set up a basic project in the chosen toolchain.
2. Processor Core Simulation
   Tool: QEMU (Open-source) / *ARM DS-5* (Licensed)
   Task:
   Simulate a RISC-V/ARM core using QEMU.
   Analyze pipeline stages and instruction execution.
3. Cache Memory Performance Analysis
   Tool: gem5 (Open-source)
   Task:
   Model L1/L2 caches in gem5.
   Compare hit/miss rates for different cache configurations.
4. Bus Arbitration & AMBA AHB Simulation
   Tool: *SystemC/TLM-2.0* (Open-source)
   Task:
   Implement a simple AMBA AHB bus with arbitration logic.
   Simulate multi-master contention scenarios.
5. NoC (Network-on-Chip) Design
   Tool: BookSim2 (Open-source) / Noxim (Open-source)
   Task:

Model a 2D mesh NoC topology.

Analyze latency and throughput under varying traffic patterns.

6. Memory Hierarchy Optimization

Tool: Dinero IV (Open-source)

Task:

Trace memory accesses of a benchmark program.

Evaluate performance with scratchpad vs. cache memory.

7. FPGA-Based SoC Prototyping

Tool: Xilinx Vivado (Licensed) / Litex (Open-source)

Task:

Implement a soft-core (e.g., RISC-V) on an FPGA.

Interface with peripherals (UART, GPIO).

8. Power & Area Tradeoff Analysis

Tool: Synopsys Design Compiler (Licensed) / OpenSTA (Open-source)

Task:

Synthesize a small RTL design.

Compare power/area metrics for different constraints.

9. Custom Instruction Set Extension

Tool: RISC-V GCC Toolchain (Open-source)

Task:

Add a custom instruction to a RISC-V core.

Verify using spike simulator.

10. SoC Verification with UVM

Tool: Verilator + UVM (Open-source) / Cadence Xcelium (Licensed)

Task:

Develop a UVM testbench for a simple SoC module.

Run functional coverage checks.

Lab Setup Recommendations:

Open-source stack: gem5 + QEMU + RISC-V tools + Verilator.

Licensed tools (if available): Cadence/Synopsys for industry-grade flows.

FPGA boards: Xilinx Artix-7 or Lattice ECP5 for hands-on prototyping.

These labs balance theory and hands-on practice, preparing students for both academic and industry challenges in SoC design.

Tools/Platforms:

Category	Open-Source	Licensed
Simulation	QEMU, gem5, Spike	ARM DS-5, Synopsys VCS
Synthesis	Yosys + OpenSTA	Synopsys Design Compiler
FPGA Prototyping	Litex, Verilator	Xilinx Vivado, Intel Quartus
Verification	Verilator + UVM	Cadence Xcelium

Textbooks:

1. Michael J. Flynn and Wayne Luk, Computer System Design System-on-Chip, Wiley India Pvt. Ltd.

2. Steve Furber, ARM System on Chip Architecture, 2ndEdition, 2000, Addison Wesley Professional

Reference books:

1. Ricardo Ries, Design of System on a Chip: Devices and Components, 1stEdition, 2004, Springer

2. Jason Andrews, Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology), Newnes, BK and CDROM.
3. Prakash Rashinkar, Peter Paterson and Leena Singh L, System on Chip Verification Methodologies and Techniques, 2001, Kluwer Academic Publishers

Course Name: Natural Language Processing

Course Code: EC41T

Category: Professional Elective Course

Preamble:

Natural Language Processing (NLP) bridges the gap between human communication and computational systems, enabling machines to understand, interpret, and generate language. This course introduces foundational concepts—from probability and linguistics to advanced algorithms like Hidden Markov Models and WordNet—equipping students to tackle real-world NLP challenges. Through a blend of theory and practical techniques, learners will explore key tasks such as tokenization, POS tagging, semantic analysis, and applications like machine translation and sentiment analysis. Emphasis is placed on overcoming ambiguities in language processing while leveraging statistical and knowledge-based approaches. By the end, students will gain the skills to design and implement NLP systems for diverse domains.

Pre-requisites:

1. Basic Programming (Python/R)
2. Introductory Statistics
3. Probabilistic Graphical Models

Course Objectives:
After completing this course, students will be able to:

- To understand natural language processing and to learn how to apply basic algorithms in this field.
- To get acquainted with the basic concepts and algorithmic description of the main language levels:
  morphology, syntax, semantics, and pragmatics.
- To design and implement applications based on natural language processing

Course Outcomes:
Learners will be able to:

CO1: Have a broad understanding of the field of natural language processing.
CO2. Understand the mathematical and linguistic preliminaries necessary for various processes in NLP
CO3. Be able to Design, implement and test algorithms for NLP problems
CO4. Perform Word-Level, Syntax-Level and Semantic-Level Analysis
CO5. Develop basic understanding of Pragmatics in NLP
CO6. Be able to apply NLP techniques to design real world NLP applications

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Natural Language Processing	1.1 The need of NLP. Generic NLP system, Levels of NLP 1.2 Stages in building a Natural Language Processing System. Challenges and ambiguities in NLP Design	2
2	Mathematical and Linguistic Preliminaries	2.1 Probability Theory, Conditional Probability and Independence, Bayes Rule, Random Variables, Probability Distributions, Statistics, Counting, Frequency, Mean and Variance 2.2 English Grammar, Parts of Speech, Phrase Structures	6
3	Word Level Analysis	3.1 Tokenization, Segmentation, Lemmatization, Edit Distance, Collocations, Porter Stemmer, N-gram Language Model 3.2 Morphological Analysis, Derivational and Reflectional Morphology	6
4	Syntax-Analysis	4.1 Tag set for English, Penn Tree bank, Introduction to Parts of Speech Tagging (POST) 4.2 Markov Processes, Hidden Markov Models (HMM) 4.2 Parts of Speech Tagging using Hidden Markov Models, Viterbi Algorithm	8
5	Semantic Analysis	5.1 Lexical Semantics, ambiguous words, word senses, Relations between senses: synonym, antonym, reversives, hyponym, hypernym, meronym, structured polysemy, metonymy, zeugma 5.2 Introduction to WordNet, gloss, synset, sense relations in WordNet. Cosine distance between documents. Word sense disambiguation, Knowledge based approach (Lesk's algorithm)	4
6	Pragmatics and	6.1 Reference resolution: Discourse model, Reference Phenomenon, Syntactic and Semantic Constraints on	4

	applications of NLP	co reference, Anaphora resolution using Hobb's algorithm 6.2 Applications of NLP: Categorization, Summarization, Sentiment Analysis, Named Entity Recognition, Machine Translation, Information Retrieval, Question Answer System	
Total			**30**

Textbooks:

1. Daniel Jurafsky, James H. Martin, Speech and Language Processing‖ Second Edition, Prentice Hall.
2. Christopher D. Manning and Hinrich Schutze, Foundations of Statistical Natural Language Processing,

Reference books:

1. Steven Bird, Ewan Klein, Natural Language Processing with Python, O'Reilly
2. Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin (Editor), The Handbook of Computational Linguistics and Natural Language Processing

Course Name: Natural Language Processing Lab

Course Code: EC41P

Category: Professional Elective Course

Preamble:
The lab sessions in this course are designed to provide hands-on experience with core NLP techniques, bridging theoretical concepts with real-world implementation. Students will work on tasks such as tokenization, morphological analysis, POS tagging using HMMs, word sense disambiguation, and sentiment analysis using Python and popular NLP libraries. Through experiments like building n-gram models, applying the Viterbi algorithm, and leveraging WordNet, learners will develop problem-solving skills for linguistic challenges. Emphasis is placed on data preprocessing, algorithm tuning, and evaluating model performance. By the end of the lab sessions, students will be equipped to design, debug, and optimize NLP pipelines for diverse applications.

Pre-requisites:
- Programming Fundamentals (Python/R)
- Basic Statistics

Course Objectives:
After completing this lab course, students will be able to:

- Develop hands-on proficiency in implementing core NLP techniques—such as tokenization, POS tagging, and semantic analysis—using Python and modern NLP libraries (e.g., NLTK, spaCy).
- Design and evaluate statistical and machine learning models for NLP tasks (e.g., HMMs for POS tagging, n-gram language models, sentiment analysis) while addressing real-world challenges like ambiguity and data sparsity.
- Apply NLP pipelines to solve domain-specific problems (e.g., information retrieval, question answering) by integrating preprocessing, algorithms, and performance metrics (accuracy, F1-score).

Course Outcomes:
Upon completion, learners will be able to:

CO1: Design, code, and evaluate NLP workflows—such as text preprocessing (tokenization, stemming), feature extraction (n-grams, TF-IDF), and model training—using Python tools (NLTK, spaCy).

CO2: Students will demonstrate the ability to build and optimize models (e.g., HMMs for POS tagging, word sense disambiguation with WordNet) and interpret results using metrics like accuracy, perplexity, or F1-score

CO3: Students will develop solutions for applications like sentiment analysis, named entity recognition, or information retrieval, while addressing challenges such as ambiguity, scalability, and noisy text.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Lab Experiments:

- "Tokenization and Text Preprocessing: Implementing Word Segmentation, Stemming, and Lemmatization"
  (Covers: Tokenization, Porter Stemmer, Lemmatization)
- "N-gram Language Models: Building and Evaluating Unigram, Bigram, and Trigram Models with Smoothing"
  (Covers: N-grams, Probability Distributions, Perplexity Evaluation)
- "Parts-of-Speech Tagging Using Hidden Markov Models and the Viterbi Algorithm" (Covers: HMMs, Penn Treebank Tagset, Viterbi Decoding)
- "Word Sense Disambiguation: Implementing Lesk's Algorithm with WordNet" (Covers: Lexical Semantics, Synsets, Lesk's Algorithm)
- "Sentiment Analysis: Machine Learning vs. Lexicon-Based Approaches for Document Classification"
  (Covers: Applications, Cosine Similarity, Sentiment Lexicons)
- "Named Entity Recognition (NER) Using Conditional Random Fields (CRFs) or spaCy" (Covers: Tagging, Statistical Models, Entity Extraction)
- "Anaphora Resolution: Implementing Hobbs' Algorithm for Coreference Resolution" (Covers: Discourse Models, Reference Resolution, Syntactic Constraints)
- "Building a Simple Question-Answering System Using TF-IDF and Cosine Similarity" (Covers: Information Retrieval, Vector Space Models, Applications)

Tools/Platforms:

1. **Tools/Libraries**: Suggest using Python with NLTK, spaCy, scikit-learn, or Hugging Face for implementation.
2. **Extensions**: Experiments 3, 5, and 8 can be scaled into mini-projects.
3. **Evaluation**: Include metrics like accuracy (POS/NER), F1-score (Sentiment/QA), or perplexity (N-grams).

Textbooks:

1. Daniel Jurafsky, James H. Martin, Speech and Language Processing|| Second Edition, Prentice Hall.
2. Christopher D. Manning and Hinrich Schutze, Foundations of Statistical Natural Language Processing,

Reference books:

1. Steven Bird, Ewan Klein, Natural Language Processing with Python, O'Reilly

2. Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin (Editor), The Handbook of Computational Linguistics and Natural Language Processing

Course Name: Mixed Signal VLSI Design

Course Code: EC44T

Category: Professional Elective Course

Preamble:

In the era of highly integrated electronic systems, the convergence of analog and digital circuitry on a single chip, commonly referred to as Mixed Signal VLSI Design, plays a critical role in enabling advanced functionalities across a range of applications, from communication systems to biomedical devices. This subject introduces students to the principles, methodologies, and design techniques essential for developing integrated circuits that process both analog and digital signals. It emphasizes the challenges of noise, signal integrity, power consumption, and layout intricacies, while also addressing current trends such as data converters (ADC/DAC), PLLs, and mixed-signal SoCs. Through a combination of theoretical learning and practical design experience, students will be equipped to tackle real-world mixed-signal VLSI design challenges and contribute effectively to the semiconductor industry.

Pre-requisite:

1. Basics of VLSI Design
2. Digital System Design
3. Advanced VLSI Design
4. Analog IC Design

Course Objectives:

1. Introduce the fundamentals of mixed signal VLSI design flow, CMOS technology, and layout challenges in integrated analog-digital systems.
2. Understand and evaluate key performance specifications and error sources in DAC and ADC systems.
3. Analyze and compare various DAC and ADC architectures and their practical implementation aspects.
4. Explore the design and operation of switched capacitor circuits, including sampling techniques and amplifier configurations.
5. Study the principles, types, and applications of oscillators and PLLs in mixed-signal integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:
CO1: Explain the mixed-signal VLSI design flow and identify key layout challenges specific to analog-digital integration.
CO2: Evaluate performance specifications of DACs and ADCs and assess their impact on signal integrity.
CO3: Compare different data converter architectures and determine their suitability for various applications.
CO4: Design and simulate switched capacitor circuits for amplification and integration tasks.
CO5: Analyze oscillator and PLL designs and their applications in modern communication and clock systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Mixed Signal VLSI**	06
	1.1	Overview of Mixed Signal VLSI Design Flow, CMOS Technology Overview (Analog & Digital), Need for Mixed Signal ICs	
	1.2	Mixed Signal Layout issues like, floor planning, power supply and ground issues, fully differential design, guard rings, shielding, interconnect considerations	
2		**Data Converter Fundamentals**	06
	2.1	**DAC Specifications:** Differential Non-linearity, Integral Non-linearity, Offset, Gain Error, Latency, Signal to Noise Ratio (SNR), Dynamic Range	
	2.3	**ADC Specifications:** Quantization Error, Differential Non-linearity, missing codes, Integral Non-linearity, Offset, Gain Error, aliasing, Signal to Noise aperture error	
3		**Data Converter Architectures**	06
	3.1	**DAC architectures:** Digital input code, Resistor String and mismatch errors, R-2R ladder network, Current steering DAC, Charge scaling DACs, Cyclic DAC, Pipeline DAC	
	3.2	**ADC architectures:** Flash ADC, two step Flash ADC, Pipeline ADC, Integrating ADC, and Successive approximation ADC	
4		**Switched Capacitor Circuits**	06
	4.1	General Considerations **Sampling Switches:** MOSFETs as switches, Speed considerations, Precision Considerations, Charge injection cancellation.	
	4.2	**Switched Capacitor Amplifier:** Unity gain buffer, non-inverting amplifier and precision multiply by two circuits. Switched Capacitor Integrator & Switched Capacitor Common Mode Feedback	
5		**Oscillators and Phase Locked Loops**	06
	5.1	**Oscillators:** General considerations, Ring oscillators, LC oscillators, VCO	

	5.2	**Phase locked loops:** Simple PLL, Charge pump PLL, Non-ideal effects in PLL, Delay locked loops and applications of PLL in integrated circuits	
		Total	**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Design of Analog CMOS Integrated Circuits	Behzad Razavi	Tata McGraw Hill	2nd	1,2,3,4,5
2	CMOS Circuit Design, Layout, and Simulation	R. Jacaob Baker, Harry W. Li, David E. Boyce	Wiley	2nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	CMOS Circuit Design, Layout and Simulation	Baker Li Boyce	Wiley	3rd	1,2,3,4,5
2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4th Edition	3,4,5
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4th Edition	1,2,3,4,5
5	Basics of CMOS Cell Design	Etienne Sicard and Sonia Delmas Bendhia	Tata McGraw Hill	4th	1,2,3,4,5
6	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5th	1,2,3,4,5
7	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3rd	1,2,3,4,5

Course Name: Mixed Signal VLSI Design Lab

Course Code: EC44P

Category: Professional Elective Course

Preamble:

The Mixed Signal VLSI Design Lab provides hands-on experience in designing, simulating, and analyzing circuits that integrate both analog and digital components on a single chip. This lab complements theoretical learning by enabling students to implement and verify key mixed-signal building blocks such as data converters, switched capacitor circuits, oscillators, and PLLs using industry-standard EDA tools. Through practical exposure to circuit-level design, layout, and verification, students will develop the skills necessary to address real-world design challenges in the semiconductor industry. The lab also fosters problem-solving, critical thinking, and design optimization techniques, preparing students for advanced work in mixed-signal integrated circuit design.

Pre-requisite:

1. Basics of VLSI Design
2. Digital System Design
3. Advanced VLSI Design
4. Analog IC Design

Course Objectives:

1. Introduce the fundamentals of mixed signal VLSI design flow, CMOS technology, and layout challenges in integrated analog-digital systems.
2. Understand and evaluate key performance specifications and error sources in DAC and ADC systems.
3. Analyze and compare various DAC and ADC architectures and their practical implementation aspects.
4. Explore the design and operation of switched capacitor circuits, including sampling techniques and amplifier configurations.
5. Study the principles, types, and applications of oscillators and PLLs in mixed-signal integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:
CO1: Explain the mixed-signal VLSI design flow and identify key layout challenges specific to analog-digital integration.
CO2: Evaluate performance specifications of DACs and ADCs and assess their impact on signal integrity.
CO3: Compare different data converter architectures and determine their suitability for various applications.
CO4: Design and simulate switched capacitor circuits for amplification and integration tasks.
CO5: Analyze oscillator and PLL designs and their applications in modern communication and clock systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Design Flow Demonstration	Implement a simple mixed-signal design using a standard EDA tool (e.g., Cadence). Demonstrate the steps: schematic, simulation, layout, and verification	CO1
2	1	CMOS Inverter Analysis	Simulate analog and digital characteristics (rise/fall time, noise margin) of a CMOS inverter.	CO1
3	1	Layout of Differential Pair with Guard Ring	Design and layout of differential pair circuits, incorporating guard rings and proper floor planning practices.	CO1
4	2	DAC Linearity Analysis	Simulate a simple R-2R ladder DAC and measure parameters like DNL and INL using a testbench.	CO2
5	2	ADC Quantization Noise Study	Implement a basic SAR ADC model and analyze quantization noise and SNR with different input signals.	CO2
6	2	Error Analysis in Converters	Simulate the effect of offset and gain errors in DAC and compare with theoretical expectations.	CO2
7	3	Design of 4-bit Flash ADC	Implement and simulate a Flash ADC using comparators and resistor ladders; test speed and accuracy.	CO3
8	3	SAR ADC Design and Timing Simulation	Design a SAR logic and capacitor array for a SAR ADC and simulate conversion timing.	CO3

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
9	3	Pipeline DAC Simulation	Create a simple pipeline DAC architecture in SPICE or Verilog-A and analyze output behavior.	CO3
10	4	MOSFET Switch Behavior	Simulate a MOSFET as a sampling switch under different frequencies and analyze charge injection.	CO4
11	4	Switched Capacitor Integrator	Design and simulate an SC integrator and measure output for sinusoidal and step inputs.	CO4
12	4	Switched Capacitor Amplifier	Implement a non-inverting SC amplifier and observe gain stability and precision behavior.	CO4
13	5	Ring Oscillator Design	Design a 3-stage ring oscillator and observe frequency behavior with varying supply voltages and transistor sizes.	CO5
14	5	VCO Design and Simulation	Create a Voltage-Controlled Oscillator (VCO) and simulate its frequency tuning range.	CO5
15	5	PLL Modeling	Simulate a basic Charge Pump PLL in MATLAB or Verilog-A; study lock-in behavior and phase noise.	CO5

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Design of Analog CMOS Integrated Circuits	Behzad Razavi	Tata McGraw Hill	2nd	1,2,3,4,5
2	CMOS Circuit Design, Layout, and Simulation	R. Jacaob Baker, Harry W. Li, David E. Boyce	Wiley	2nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	CMOS Circuit Design, Layout and Simulation	Baker Li Boyce	Wiley	3rd	1,2,3,4,5
2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4th Edition	3,4,5

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4th Edition	1,2,3,4,5
5	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5th	1,2,3,4,5
6	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3rd	1,2,3,4,5

Detailed Syllabus of Open Elective Courses

Course Name: Cyber Law

Course Code: OE21

Category: Open Elective

Preamble:
This course explores the evolving landscape of cyber law and security, equipping students with legal frameworks and technology insights necessary to navigate the challenges posed by digital crimes. It emphasizes both technical and legal aspects of cybersecurity, with a focus on Information Technology Act, 2000 (ITA 2000) and the amendments in the Information Technology Amendment Act, 2008 (ITAA 2008).

Pre-requisites: Nil

Course Objectives:

- To introduce students to the legal framework governing cyber activities, with a focus on ITA 2000 and ITAA 2008.
- To understand the technical foundations of cybersecurity and the role of various security mechanisms in preventing cyber threats.
- To explore different types of cybercrimes and the processes involved in investigating and addressing them.
- To examine the legal aspects of e-commerce, e-governance, and the use of electronic signatures in Indian law.
- To analyse the importance of privacy, data protection, and how international laws influence Indian regulations.
- To provide a global perspective on cyber law and international conventions, addressing challenges like intellectual property and cyber warfare.

Course Outcomes:

Student will be able to:
CO1: Explain the key provisions of ITA 2000 and ITAA 2008 and their impact on various legal domains.
CO2: Gain practical knowledge of cybersecurity tools and techniques such as encryption, firewalls, and digital signatures.
CO3: Identify different types of cybercrimes and apply forensic techniques to investigate digital crimes.
CO4: Assess the legal implications of e-commerce, e-governance, and electronic contracts in India.
CO5: Analyze privacy and data protection laws in India and evaluate them from an international perspective.
CO6: Understand global cyber law frameworks and how international treaties impact the regulation of cyberspace in India.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester

.**Detailed Syllabus:**

Module no	Module name	Content	No of Hours
1	Introduction to Cyber Law and IT Act	Evolution and necessity of ITA 2000 Overview of ITA 2000 and ITAA 2008: Key provisions, authorities, and penalties Amendments to Indian Penal Code, Evidence Act, and other laws Case studies on jurisdiction under cyber law	6
2	Cyber Security Framework	Definition and importance of cybersecurity Overview of threats: hacking, malware, phishing, and cyberterrorism Basic security mechanisms: firewalls, encryption, PKI, and digital signatures Role of CERT-IN and other agencies in India	7
3	Cyber Crimes and Investigation	Types of cybercrimes: data theft, identity theft, cyberstalking, cyberbullying, and online fraud Investigation procedures for cybercrimes Seizure of digital evidence and forensic procedures Digital forensics: tools and anti-forensics measures	8
4	E-Commerce, E-Governance, and Cyber Law	E-commerce regulations under ITA 2000 and ITAA 2008 Validity of electronic signatures and contracts in Indian law E-Governance and issues in e-taxation Cyber Tribunal and appellate processes	8
5	Privacy, Data Protection, and Emerging Trends	Sensitive Personal Data or Information (SPDI) under Indian law International perspectives on data protection and privacy (GDPR, HIPAA) Impact of cloud computing and data localization Case studies on privacy violations and legal recourse	8
6	International Cyber Law and Legal Framework	UNCITRAL model law and international conventions on cybercrime Intellectual property rights in cyberspace: trademarks, patents, and copyright Cyber warfare, digital sovereignty, and human rights Cyber law practices in other jurisdictions (US, EU, China)	8
Total			**45**

Textbooks:

1. "Cyber Law & Cyber Crimes" by Advocate Prashant Mali, Snow White Publications, Mumbai.

2. "Information Technology Law and Practice" by Vakul Sharma, Universal Law Publishing Co. Pvt. Ltd.
3. "The Indian Cyber Law" by Suresh T. Vishwanathan, Bharat Law House, New Delhi.

Reference Books:

1. "Digital Evidence and Computer Crime" by Eoghan Casey, Academic Press.
2. "Cyber Law in India" by Farooq Ahmad, Pioneer Books.
3. "Computer Forensics: Principles and Practices" by Linda Volonino et al., Pearson Prentice-Hall, 2007.

Course Name: Project Management

Course Code: OE22

Category: Open Elective

Preamble:
This course discusses tools that any organization can use to improve its ability to plan, implement, and control its activities as well as the ways in which it utilizes its people and resources.

Pre-requisites: Nil

Course Objectives:

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Course Outcomes:

Student will be able to:
CO1. Apply selection criteria and select an appropriate project from different options.
CO2. Write work break down structure for a project and develop a schedule based on it.
CO3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
CO4. Use Earned value technique, determine & predict status of the project.CO5. Capture lessons learned during project phases and document them for future reference

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Project Management Foundation	Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	6
2	Initiating Projects	How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter, Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	8
3	Project Planning and Scheduling	Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS)	8
4	Planning Projects	Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	8
5	Executing Projects, Monitoring and Controlling Projects and Project Contracting	Executing Projects: Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. Project Contracting: Project procurement management, contracting and outsourcing	8
6	Project Leadership and Ethics Closing the Project	Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects. Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process	7

		of project termination, completing a final report; doing a lesson learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study	
Total			**45**

Reference Books:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7 th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Course Name: Product Life Cycle Management

Course Code: OE23

Category: Open Elective

Preamble:

This course aims to give students an overview of product Life Cycle Management (PLM) which is a strategic approach to managing the entire lifecycle of a product, from its inception through design, manufacturing, deployment, and disposal. This course gives student insights on various aspects such as PLM Strategies, Product design, Product Data Management, Virtual Product Development Tools, Integration of Environmental Aspects in Product Design, Life Cycle Assessment and Life Cycle Cost Analysis

Pre-requisites: Nil

Course Objective:

- To familiarize the students with the need, benefits and components of PLM
- To acquaint students with Product Data Management & PLM strategies
- To give insights into new product development program and guidelines for designing and developing a product
- To familiarize the students with Virtual Product Development

Course Outcomes:

Students will be able to:
CO1: Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
CO2: Illustrate various approaches and techniques for designing and developing products.
CO3: Apply product engineering guidelines / thumb rules in designing products for molding, machining, sheet metal working etc.
CO4: Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the

commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Product Lifecycle Management and PLM Strategies	**Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM	10
2	Product Design	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering. and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	10
3	Product Data Management (PDM)	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	06
4	Virtual Product Development Tools	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case Studies	07
5	Integration of Environmental Aspects in Product Design	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental	06

		Strategies, Useful Life Extension Strategies, End-of- Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	
6	Life Cycle Assessment and Life Cycle Cost Analysis	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	06
Total			**45**

Textbooks:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229

Reference Books:

1. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
2. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Name: Sustainability Management

Course Code: OE24

Category: Open Elective

Preamble:

To provide learners with a comprehensive understanding of sustainability principles, strategies, and management practices that enable organizations to operate responsibly while achieving long-term success.

Pre-requisites: Nil

Course Objectives:

- To provide a comprehensive understanding of sustainability concepts and their importance in global and organizational contexts.
- To equip participants with the tools and frameworks to develop and implement effective sustainability strategies.
- To foster the ability to analyze environmental, social, and economic impacts and propose practical solutions.
- To empower learners to lead and manage sustainable practices through innovation, technology, and ethical decision-making.

Course Outcomes:

Learner will be able to:

CO1: Understand the Core Principles of Sustainability: Comprehend the key environmental, social, and economic dimensions of sustainability

CO2: Analyze Environmental Impacts: Evaluate organizational and societal environmental footprints and recommend sustainable practices.

CO3: Develop Strategies for Social and Economic Sustainability: Formulate strategies that address social equity, community engagement, and economic resilience.

CO4: Implement Sustainability Practices: Design and implement sustainability strategies within an organizational context, including reporting and stakeholder management.

CO5: Leverage Technology and Innovation: Utilize emerging technologies to enhance sustainability outcomes.

CO6: Lead and Manage Change: Apply leadership and change management principles to foster a sustainability-focused culture.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by

a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Sustainability	Overview of Sustainability: Definition, history, and importance. Sustainable Development Goals (SDGs): UN's 2030 Agenda and its impact on global development. Three Pillars of Sustainability: Environmental, social, and economic dimensions. Current Challenges: Climate change, resource depletion, inequality, and global initiatives.	5
2	Environmental Sustainability	Understanding Environmental Impact: Carbon footprint, waste management, and biodiversity. Energy Management: Renewable energy sources, energy efficiency, and innovations in energy systems. Circular Economy: Concepts, examples, and transitioning to closed-loop systems. Sustainable Resource Management: Water, minerals, and sustainable agriculture.	8
3	Social Sustainability	Social Equity and Inclusion: Addressing diversity, equity, and inclusion in organizations. Community Engagement: Building partnerships and contributing to societal development. Labor Practices: Ethical employment practices, health, and safety. Corporate Social Responsibility (CSR): Importance, frameworks, and success stories.	7
4	Economic Sustainability	Sustainable Business Practices: Triple bottom line approach. Green Finance: ESG investing, green bonds, and carbon pricing. Sustainable Innovation: Developing products and services that align with sustainability goals. Regulatory Frameworks: Policies and standards for sustainable business operations.	5
5	Sustainability Strategy & Implementation	Developing a Sustainability Strategy: Key steps and tools. Stakeholder Engagement: Identifying and collaborating with key stakeholders. Sustainability Reporting: Standards (GRI, SASB), metrics, and case studies. Measuring Impact: Life cycle assessment (LCA), carbon accounting, and sustainability indicators.	8
6	Technology and Innovation for	Digital Transformation: Role of AI, IoT, and big data in achieving sustainability.	6

	Sustainability	Green Technologies: Innovations in clean energy, transportation, and waste management. Smart Cities: Integration of sustainable technologies in urban planning. Role of Blockchain: Transparency and traceability in sustainability practices.	
7	Leadership and Change Management in Sustainability	Sustainability Leadership: Characteristics and examples of successful leaders. Driving Organizational Change: Overcoming resistance and fostering a sustainability culture. Ethical Decision Making: Frameworks for responsible leadership. Global Case Studies: Examining successful implementations of sustainability initiatives.	6
Total			**45**

Textbooks:

1. "Sustainability Principles and Practice" by Margaret Robertson.
2. "The Triple Bottom Line" by Andrew Savitz.
3. "The Business Guide to Sustainability" by Darcy Hitchcock and Marsha Willard.

Reference Books:

1. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
2. "Sustainability: A Systems Approach" by Tony Clayton and Nicholas Radcliffe.

Course Name: Operations Research

Course Code: OE25

Category: Open Elective

Preamble:
This course discusses various tools in scientific management.

Pre-requisites: Nil

Course Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Course Outcomes:

Learner will be able to…

CO1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
CO2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
CO3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
CO4. Understand the applications of integer programming and a queuing model and compute important performance measures

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Operations Research	**Introduction to Operations Research**: Introduction, Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem:** Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the steppingstone method and MODI method. **Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem:** Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	15
2	Queuing models	Queuing models: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	6
3	Simulation	Simulation: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	6
4	Dynamic programming	Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stagecoach/Shortest Path, cargo loading and Reliability problems.	6

5	Game Theory	Game Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	6
6	Inventory Models	Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	6
Total			**45**

Reference Books:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Name: IPR and Patenting

Course Code: OE26

Category: Open Elective

Preamble:

This course discusses legal rights that can be registered with a legal authority in some presentable or tangible form which can be sold or bought or licensed, like physical property given to creator or innovator to harvest the economic benefits on their invention or creation.

Pre-requisites: Nil

Course Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as international treaty procedures
- To get acquaintance with Patent search and patent filing procedure and applications

Course Outcomes:

Learner will be able to…
CO1: Understand Intellectual Property assets
CO2: Assist individuals and organizations in capacity building
CO3: Work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Intellectual Property Rights (IPR):	Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. Importance of IPR in Modern Global Economic Environment: Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	6
2	Enforcement of Intellectual Property Rights:	Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, international agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement Indian Scenario of IPR: Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	8
3	Emerging Issues in IPR:	Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc	6
4	Basics of Patents:	Definition of Patents, Conditions of patentability, Patentable and nonpatentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	8
5	Patent Rules:	Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	9
6	Procedure for Filing a Patent (National and International):	Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement Patent databases: Important websites, Searching international databases	8
Total			**45**

Reference Books:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting, Interpretation of Patent Specifications and Claims, New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Course Name: Research Methodology

Course Code: OE27

Category: Oen Elective

Preamble:

This course offers "An overview of research methodology including basic concepts employed in quantitative and qualitative research methods. Includes computer applications for research.

Pre-requisites: Nil

Course Objectives:

- To understand Research and Research Process
- To acquaint students with identifying problems for research and develop research strategies
- To familiarize students with the techniques of data collection, analysis of data and interpretation

Course Outcomes:

Students will be able to:

CO1: Demonstrate the ability to choose methods appropriate to research aims and objectives

CO2: Understand the limitations of particular research methods

CO3: Develop skills in qualitative and quantitative data analysis and presentation

CO4: Develop advanced critical thinking skills

CO5: Demonstrate enhanced writing skills

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction and Basic Research Concepts	Introduction and Basic Research Concepts 1.1 Research – Definition: Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology 1.2 Need of Research in Business and Social Sciences 1.3 Objectives of Research 1.4 Issues and Problems in Research 1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	10
2	Types of Research	Types of Research 2.1. Basic Research 2.2. Applied Research 2.3. Descriptive Research 2.4. Analytical Research 2.5. Empirical Research 2.6 Qualitative and Quantitative Approaches	8
3	Research Design and Sample Design	Research Design and Sample Design 3.1 Research Design – Meaning, Types and Significance 3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	9
4	Research Methodology	Research Methodology 4.1 Meaning of Research Methodology 4.2. Stages in Scientific Research Process: a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report	8
5	Ethics in Research	Ethics in Research Plagiarism - Definition, different forms, consequences, unintentional plagiarism, copyright infringement, collaborative work. Qualities of good Researcher.	5
6	ICT Tools for Research	ICT Tools for Research: Role of computers in research, maintenance of data using software such as Mendeley, Endnote, Tabulation and graphical presentation of research data and software tools. Web search: Introduction to Internet, use of Internet	5

		and www, using search engines and advanced search tools.	
Total			**45**

Textbooks:

1 Donald Cooper and PS Schindler (2009) Business Research Methods, 9th edition, Tata McGraw Hill.
2 Kothari C. R Research Methodology
3 Uma Sekaran (2010) Research Methods for Business, 4th edition, Wiley.
4 Ranjit Kumar (2009) Research Methodology, 2nd edition, Pearson Education
5 Naresh Malhotra and S Dash (2009) Marketing Research, 5th edition, Pearson Prentice Hall.
6 Michael V. P Research Methodology.
7 Fred N. Kerlinger: Foundations of Behavioral Research.

Reference books

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course: Renewable Energy Management

Category: Open Elective

Course Code: OE28

Preamble:

Renewable Energy Management focuses on the development, implementation, and management of renewable energy projects. This course aims to equip students with the knowledge and skills required to effectively manage renewable energy resources, assess their impact, and implement sustainable energy solutions. The curriculum covers various renewable energy technologies, their applications, and the economic, environmental, and policy aspects of renewable energy systems.

Pre-requisites: Nil

Course Outcomes:
CO1: Understand the principles and technologies of various renewable energy sources.

CO2: Analyse the economic, environmental, and social impacts of renewable energy projects.

CO3: Evaluate and design renewable energy systems for specific applications.

CO4: Develop strategies for the integration and management of renewable energy in the energy mix.

CO5: Understand the policies, regulations, and incentives related to renewable energy.

CO6: Gain practical skills in renewable energy project planning, implementation, and management.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head of Learning	ISA	MSE	Project	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Mod No.	**Module Name**	**Content**	**No. of hrs.**
1	Introduction to Renewable Energy	• Overview of global and national energy scenarios • Importance and benefits of renewable energy • Types of renewable energy sources: solar, wind, biomass, hydro, and geothermal • Comparison between renewable and non-renewable energy • Current trends and future prospects in renewable energy	7
2	Solar Thermal Energy	• Principles of solar thermal energy conversion	6

		• Solar collectors: flat plate, evacuated tube, and concentrating collectors • Solar thermal applications: water heating, space heating, and industrial processes • Solar thermal power plants: parabolic troughs, solar towers, and dish Stirling systems • Economic and environmental aspects of solar thermal energy	
3	Solar Photovoltaics	• Principles of photovoltaic energy conversion • Types of photovoltaic cells: monocrystalline, polycrystalline, and thin film • Design and components of photovoltaic systems: modules, inverters, and batteries • Performance analysis of PV systems: efficiency, shading, and temperature effects • Grid integration and energy storage for PV systems	6
4	Wind Energy	• Fundamentals of wind energy conversion • Wind turbine types, components, and operation • Wind farm design and site selection • Environmental and social impacts of wind energy projects • Economic analysis and policy considerations for wind energy	6
5	Biomass, Hydro and Geothermal Energy	• Biomass & Bio Energy • Biomass resources and conversion technologies • Bioenergy production: biogas, biofuels, and biomass power generation • Waste-to-energy systems • Environmental and economic aspects of bioenergy • Policies and incentives for bioenergy development • Hydro Energy • Principles of hydro power generation • Small-scale and large-scale hydro power plants • Geothermal Energy • Geothermal energy resources and extraction methods • Applications and challenges of geothermal energy • Environmental and economic considerations for hydro and geothermal energy	9
6	Renewable Energy and Management Policy	• Energy management principles and practices • Renewable energy project planning and management • Integration of renewable energy into the grid • Policies, regulations, and incentives for renewable energy • Case studies of successful renewable energy projects	11
Total			45

Textbooks:

1. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
2. "Renewable Energy Systems: The Earthscan Expert Guide to Renewable Energy Technologies for Home and Business" by David Thorpe
3. "Energy Management Handbook" by Wayne C. Turner and Steve Doty

Reference Books:

1. "Solar Engineering of Thermal Processes" by John A. Duffie and William A. Beckman
2. "Wind Energy Explained: Theory, Design and Application" by James F. Manwell, Jon G. McGowan, and Anthony L. Rogers
3. "Biomass to Renewable Energy Processes" by Jay Cheng
4. "Hydropower: Renewable Energy for a Sustainable Future" by Dirk Aschenbach
5. "Geothermal Energy: Renewable Energy and the Environment" by William E. Glassley
6. "Renewable Energy Policy and Politics: A Handbook for Decision-Making" by Volker M. Quaschning

Course Name: Energy Audit and Management

Course Code: OE29

Category: Open Elective

Preamble:
Energy Audit is a systematic approach for decision-making in energy management to balance the total energy inputs with its use. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilisation to minimise energy costs/waste without affecting production & quality with minimum environmental effects.

Pre-requisites: Nil

Course Objectives:

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Course Outcomes:
Student will be able to:
CO1. To identify and describe present state of energy security and its importance.
CO2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
CO3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
CO4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
CO5. To analyse the data collected during performance evaluation and recommend energy saving measures

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Energy Scenario	Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001	5

		and its Features. Basics of Energy and its various forms, Material and Energy balance	
2	Energy Audit Principles	Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	10
3	Energy Management and Energy Conservation in Electrical System	Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipment and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
4	Energy Management and Energy Conservation in Thermal Systems	Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
5	Energy Performance Assessment	On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis	5
6	Energy conservation in Buildings:	Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	5
Total			**45**

Reference Books:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy
5. Research Institute (TERI).
6. Energy Management Principles, C.B.Smith, Pergamon Press
7. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont
8. Press

9. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
10. www.energymanagertraining.
11. http://www.bee-india.nic.in

Course Name: Bioinformatics

Course Code: OE30

Category: Open elective

Preamble:

This course is designed with the objective of equipping students with a robust understanding of the integration between biology and computational science, key bioinformatics concepts, methodologies, and applications. Through a combination of theoretical knowledge and practical applications, students will develop a holistic understanding of how computational methods can enhance the comprehension of biological processes. It also emphasizes on real-world biological questions and research challenges, empowering them to make meaningful contributions to the rapidly evolving field of bioinformatics.

Pre-requisites: Nil

Course Objectives:

- To enable learners to understand the basic principles of bioinformatics.
- To provide a foundational understanding of key bioinformatics concepts, including biological data types and analysis methods.
- To develop the skills necessary for analyzing and interpreting genomic and proteomic datasets using computational techniques.
- To familiarize students with essential bioinformatics tools and databases, enabling effective selection and application in research.
- To encourage the integration of bioinformatics approaches into biological research, fostering the ability to formulate and test hypotheses.

Course Outcomes:

Learner will be able to:

CO1: Understanding of foundational bioinformatics concepts.
CO2: Comprehending and applying knowledge of basic principles of mathematics and statistics.
CO3: Implementing efficient and reliable bioinformatics solutions by optimizing the usage of existing tools. CO4: Apply problem-solving skills to multivariate methods in bioinformatics.
CO5: Search and apply bioinformatics tools to analyze and interpret biological data

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Bioinformatics	Basics of Biology: Characteristics and Principles of cells, DNA and chromosome, genes and the genomes. Types of biological data, Sequencing Methods: DNA & Protein, Genomic Sequencing, and Human Genome Project Overview and scope of Bioinformatics, Computers in biology, medicine & different problems in biology, Applications of Bioinformatics	9
2	Biological databases and their classification	Based on storage techniques (Flat, Relational, Object Oriented). Based on data (Primary, Secondary, Specialized and Composite). Search engines: Entrez& SRS Sequence databases: NCBI, EMBL, DDBJ Structural Databases: PDB Protein Databases: PIR, SWISS PROT Other Databases: Chemical and Drug Molecule Databases	9
3	Algorithms in Bioinformatics	Sequence Alignment: Heuristic Method (BLAST, FASTA) Pairwise Sequence Alignment: Local and Global Alignment (Dynamic programming Methods: Needleman Wunch Algorithm, Smith Waterman Algorithm.), Multiple Sequence Alignment: CLUSTAL W, Phylogenetic Analysis.	9
4	Introduction to drug designing	History of drug design, Stages of drug discovery and development; Drug properties, likeness. Preparation of Protein Structure: In silico Structure Prediction - Homology Modeling; Threading; Fold Recognition. Ab initio modeling; Model refinement and validation Molecular Visualization Software: Methods for representing biological data, 3D Structure Viewers Concept of pharmacophore mapping and pharmacophore based Screening	10
5	Computer aided drug designing	High throughput Virtual Screening and Molecular Docking: Rigid and Flexible Docking Analysis of Protein-Ligand interactions Quantitative Structure Activity Relationship (QSAR) (3D-QSAR approaches like COMFA and COMSIA.) Molecular Mechanics and Molecular Dynamics Simulations: Understanding the structural stability of protein and protein-ligand complex ADMET analysis	8
Total			**45**

Suggested list of Assignments:

1. Retrieving sequences, it's structural and functional data from the set of databases.
2. Analyzing sequences through alignment tools - BLAST, FASTA and CLUSTAL s.
3. 3D Protein modelling, validation and visualization
4. Protein ligand interaction by docking techniques

5. Designing a potential drug candidate.

Suggested List of Value-Added Home Assignments:

1. Mapping genes to biological pathways and analyze their interactions.
2. Construct and interpret a phylogenetic tree.

Suggested Online Courses:

1. Bioinformatics: Algorithms and Applications, offered by NPTEL Swayam, https://onlinecourses.nptel.ac.in/noc21_bt06/preview
2. Bioinformatics: Introduction and Methods, offered by Peking University through Coursera, https://coursesity.com/r/site/bioinformatics-introduction-and-methods-

Reference Books:

1. Bioinformatics and Functional genomics, Jonathan Pevsner, Wiley Blackwell, 2015, Third edition.
2. Bioinformatics: Sequence and genome analysis, David mount, Cold Spring Harbor, N.Y press, 2004, Second edition.
3. Strategies for Organic Drug Discovery Synthesis and Design, Daniel Lednicer, Wiley International Publishers, 1998, Second Edition.
4. Essential Bioinformatics, Jin Xiong, Cambridge University Press, 2006, First Edition.

Course Name: Nanotechnology

Course Code: OE31

Category: Open elective

Preamble:
The course aims to provide a comprehensive understanding of nanotechnology fundamentals, its scientific principles, fabrication techniques, applications in engineering, and the ethical considerations associated with its usage. Students will explore how nanotechnology can be applied to different fields of engineering, including electronics, materials science, biomedical applications, and energy.

Pre-requisites: Nil

Course Objectives:

- To enable learners to understand the basic principles and concepts of nanotechnology.
- To enable learners to explain the properties and behavior of materials at the nanoscale.
- To enable learners to describe the fabrication and characterization techniques used in nanotechnology.
- To enable learners to explore the applications of nanotechnology in various engineering fields.
- To enable learners to analyze the societal and ethical implications of nanotechnology advancements.

Course Outcomes:

Learner will be able to:

CO1: Understand nanotechnology fundamentals.
CO2: Analyze nanoscale phenomena
CO3: Understand and apply key nanofabrication methods for creating nanoscale structures and devices. CO4: Understand the principles behind various characterization techniques for nanoscale materials.
CO5: Explore engineering applications of nanotechnology.
CO6: Evaluate ethical, environmental, and societal Impacts.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Nanotechnology	Definition, scope, and multidisciplinary nature of nanotechnology. Historical development of nanotechnology and key breakthroughs. Types of nanomaterials: nanoparticles, nanotubes, nanowires, quantum dots, and nanocomposites. Nanoscale dimensions: importance of size, surface area, and quantum effects. Exploration of nanotechnology's role in various industries (electronics, medicine, energy, etc.).	9
2	Properties of Nanomaterials	In-depth study of the physical, chemical, electrical, optical, and mechanical properties of nanomaterials. Surface energy, surface-to-volume ratio, and its impact on material properties. Detailed study of quantum confinement and its influence on electrical and optical properties. Toxicity and environmental concerns of nanomaterials: impact on living organisms and ecosystems.	9
3	Nanofabrication Techniques	Comprehensive overview of top-down and bottom-up nanofabrication methods. In-depth study of lithographic techniques: photolithography, electron-beam lithography. Advanced deposition techniques: Chemical Vapor Deposition (CVD), Atomic Layer Deposition (ALD), Physical Vapor Deposition (PVD). Molecular self-assembly, nanoimprint lithography, and soft lithography techniques.	9
4	Characterization of Nanomaterials	Detailed study of key characterization tools: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), X-ray diffraction (XRD). Optical spectroscopy and Raman spectroscopy techniques. Importance of precision and resolution in nanomaterial characterization.	6
5	Applications of Nanotechnology in Engineering	Nanotechnology in Electronics: nanoscale transistors, quantum dots, and nanomaterials for next-gen electronics. Energy Applications: nanomaterials for solar cells, energy storage, supercapacitors, and batteries. Biomedical Applications: drug delivery, diagnostic tools, nanomedicine, and tissue engineering. Environmental Applications: nanotechnology in water purification, air filtration, and pollution control. Mechanical and Civil Engineering: nanocomposites, self-cleaning surfaces, and smart materials.	8

6	Societal, Ethical, and Environmental Implications	Ethical issues related to nanotechnology: privacy concerns, nanotoxicology, and regulation. Environmental impacts of nanomaterials: nanowaste management and recycling. Public perception of nanotechnology and its societal impacts. Responsible innovation and future directions for ethical development of nanotechnology. Regulatory frameworks for nanomaterials in India and worldwide.	4
Total			**45**

Suggested list of Assignments:

1. Explore one specific application of nanotechnology in any engineering field (e.g., electronics, medicine, or energy).
2. Comparative Analysis of Nanoscale vs. Bulk Properties.
3. Design of a Nanofabrication Process for a device.
4. Nanomaterials Characterization Report interpretation.
5. Propose a simple nanotechnology-based solution for an engineering challenge in your chosen field.
6. Ethical and Environmental Implications of Nanotechnology.

Suggested List of Value-Added Home Assignments:

1. Reviewing Nano products and new technologies.
2. Novel technical paper writing based on recent advancements.
3. Problem Based Learning on Nano sensor development.

Suggested Online Courses:

1. Nanotechnology : Introduction, Essentials, and Opportunities https://www.udemy.com/course/nanotechnology/?couponCode=IND21PM
2. Nanotechnology: A Maker's Course https://www.coursera.org/learn/nanotechnology

Reference Books:

1. Marc Madou, "Fundamentals of Microfabrication", CRC Press, 1997.
2. Charles P. Poole and Frank J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, 2003.
3. Sulabha Kulkarni, "Nanotechnology: Principles and Practices", Springer, 2015.
4. R.S. Tiwari and A. Gosh, "Nanomaterials and Nanotechnology", S. Chand & Company, 2017.
5. Patricia I. Dolez, "Nanoengineering: Global Approaches to Health and Safety Issues", Elsevier,