Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Master of Technology

in

Electronics & Telecommunication Engineering

First Year Scheme & Syllabus

(As per AICTE guidelines, with effect from the Academic Year 2024-25)

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. Autonomy curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability, problem-solving approach and research ability 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)**. Number of credits for courses learnt by learners, internships and dissertation is finalized considering the scope of study and the ability that a learner should gain through the programme.

The curriculum has core courses of engineering, specific to the branch. These courses are completed in first year of the engineering programme that enables learners to work on their chosen dissertation topic during their final year. The curriculum planned by the Institute offer flexibility and diversity to learners to choose any set of courses from a basket of professional electives. Learner can also choose to specialize in a domain as per their field of interest. The selection of unique specialization tracks based on recent developments and industrial requirements is a salient feature of this curricula ensuring employability. Each specialization track has mandatory courses positioned and sequenced to achieve sequential and integral learning for the required depth of the specific domain. Learner can choose to complete these courses in first year of the engineering program that enables him/her to prepare for research during their final year. Credits additional to core and professional elective courses, include dissertation, internships, advanced courses in the field of computer engineering, multi-disciplinary courses, special skill development courses and similar knowledge that make learner capable to do further research or work in industrial environment.

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.

Chairman, Board of Studies
Department of Electronics & Telecommunication Engineering
Vidyalankar Institute of Technology

Chairman, Academic Council
Vidyalankar Institute of Technology

First Year M. Tech. Electronics and Telecommunication Engineering **Semester: I**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
ET71T	Advanced Optical Communication Systems	Theory	3	40	20	40	-	100
ET71P		Practical	1	-	-	-	25	25
ET96T	Remote Sensing	Theory	3	40	20	40	-	100
ET96P		Practical	1	-	-	-	25	25
ET*	Professional Elective-1	Theory	3	40	20	40	-	100
ET*		Practical	1	-	-	-	25	25
ET*	Professional Elective-2	Theory	3	40	20	40	-	100
ET*		Practical	1	-	-	-	25	25
OE#	Open Elective-1	Theory	4	40	20	40	-	100

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
*Selection will be based on the subset of OE courses made available 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.

Refer Appendix-A for guidelines on Professional Elective Courses and Specialization Certificate

Professional Elective-1 Courses (ETXX) (Any one from any one track)

Course Code*	Course Name	Specialization Track Name#
ET79T ET79P	Embedded Communication Systems Design	Embedded and IoT
ET83T ET83P	Sensor Technology MEMS & NEMS	VLSI
ET92T ET92P	Fundamentals of Machine Learning	Machine Learning

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-2 Courses (ETXX) (Any one from any one track)

Course Code*	Course Name	Specialization Track Name#
ET93T ET93P	Cloud Computing & IoT	Embedded and IoT
ET84T ET84P	Analog & Mixed Signal Circuit Design	VLSI
ET94T ET94P	Data Warehousing & Mining	Machine Learning

#For details of Specialization Certificate, refer Appendix-A

Open Elective-1 Courses (OEXX) (Any one)

Course Code#	Course Name
	Teaching Pedagogy & Educational Technology
OE07	Research Methodology
OE13	MOOC-1 (Course-1) & MOOC-2 (Course-2)

First Year M. Tech. Electronics and Telecommunication Engineering **Semester: II**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
ET73T	Advanced Digital Signal Processing	Theory	3	40	20	40	-	100
ET73P		Practical	1	-	-	-	25	25
ET75T	OFDM & MIMO Technology	Theory	3	40	20	40	-	100
ET75P		Practical	1	-	-	-	25	25
ET*	Professional Elective-3	Theory	3	40	20	40	-	100
ET*		Practical	1	-	-	-	25	25
ET*	Professional Elective-4	Theory	3	40	20	40	-	100
ET*		Practical	1	-	-	-	25	25
OE#	Open Elective-2	Theory	4	40	20	40	-	100

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
*Selection will be based on the subset of OE courses made available 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-3 Courses (ETXX) (Any one from any one track)

Course Code*	Course Name	Specialization Track Name#
ET81T ET81P	Smart Sensors & IoT	Embedded and IoT
ET85T ET85P	VLSI & Signal Processing	VLSI
ET97T ET97P	Industrial Data Analytics & Optimization	Machine Learning

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-4 Courses (ETXX) (Any one from any one track)

Course Code*	Course Name	Specialization Track Name#
ET98T ET98P	Industrial IoT	Embedded and IoT
ET86T ET86P	Integrated Circuits for Wireless Communication	VLSI
ET99T ET99P	Machine Learning	Machine Learning

#For details of Specialization Certificate, refer Appendix-A

Open Elective-2 Courses (OEXX) (Any one)

Course Code#	Course Name
OE06	IPR & Patenting
OE04	Sustainability Management
OE14	MOOC-3 (Course-3) & MOOC-4 (Course-4

Detailed syllabus of First Year Semester-I

Course Name: Advanced Optical Communication Systems

Course Code: ET71

Category: Core

Preamble:

The objective of the course is to impart knowledge of Advanced optical system which are used in communication. This will help learners to understand the functioning and implementation of optical systems to enhance data rates and reliability of a communication system.

Pre-requisites:

Applied Physics, Applied Mathematics

Course objectives:

- The objective of this course is to introduce the learners to the fundamental basics and understanding of fiber optical communication.
- This includes the properties of optical fibers and how are they used to establish optical links for communication systems.
- Learners will be able to design an optical link by choosing various parameters and components.

Course Outcomes:

Learner will be able to:

CO1: Apply the knowledge of fundamental transmission characteristics of optical fiber.

CO2: Calculate parameters for optical link budgeting and analyse the link.

CO3: Identify working principles of various components of all optical network.

CO4: Identify issues related to signal degradation due to multiplexing.

CO5: Explore concepts of designing and operating principles of modern optical communication system and network.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	1

Evaluation Scheme:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Transmission characteristics of optical fibre	Attenuation, absorption, linear and nonlinear scattering losses, bending losses, modal dispersion, waveguide dispersion, dispersion and pulse broadening, dispersion shifted and dispersion flattened fibers.	9
2	Optical Link	Introduction, Point to point links, system considerations, link power budget, and rise time budget. RF over fiber, key link parameters, Radio over fiber links, microwave photonics.	9
3	Nonlinear Optics	Overview of Non linearities, Stimulated Raman scattering, Stimulated Brillouin scattering, self phase and cross phase modulation, four wave mixing, Solitons, properties of solitons, optical switching, parametric amplification	9
4	Optical network components	Optical Sources (Quantum well lasers), Optical detectors (RCE and RCEPD), RCE avalanche photo diode, Optical amplifiers, WADMA, Optical cross connects.	9
5	Introduction to optical networks	Overview of generations of optical Networks, SONET& SDH: Multiplexing hierarchy, Multiplexing structure – Functional components, Problem detection, Virtual tributaries & containers Optical Transport Network: Hierarchy, Frame structure, Multiplexing	6
6	WDM Network Design	Cost Trade-offs: A detailed Ring Network example, LTD and RWA Problems, Routing and Wavelength assignment Dimensioning wavelength networks, Statistical wavelength routing networks- First passage model, Blocking model Maximum load dimensioning models- offline Lightpath request, online RWA in Rings	3
Total			**45**

Suggested list of Practicals:

1. Performance analysis of optical link in presence of group velocity dispersion
2. Performance Analysis of Optical Link with Different Sources
3. Performance Analysis of Optical Link with Different Detectors
4. Performance Analysis of Soliton Communication System
5. Effect of cross phase modulation on WDM system
6. Mitigation of Four wave mixing by NZ-DSF fiber
7. Performance Analysis of Optical Amplifier
8. Performance Analysis of DWDM System

Text Books:

1. JM Senior, "Optical fiber communication", 3rd Edition, Pearson Education 2009
2. GP Agarwal, "Nonlinear fiber optics", 2nd Edition, Pearson Education 2013

Reference Books:

1. Uyless Black, "Optical networks, third generation transport systems", 2nd Edition, Pearson,

Course Name: Remote Sensing

Course Code: ET96

Category: Core

Course Pre-requisite: None

Course Objective:

1. To provide exposure to students in gaining knowledge on concepts and applications of Remote Sensing
2. To give exposure to participants for Digital Image Processing with more emphasis on classification
3. To acquire skills in advance techniques such as hyper spectral, thermal and microwave for mapping and monitoring.

Course Outcome: Learner will be able to

1. Demonstrate detailed, integrated knowledge of the application and history of remote sensing
2. Discuss the nature of electromagnetic radiation and its interaction with the earth's surface and atmosphere
3. Demonstrate a critical understanding of the differences between remote sensing systems and be aware of their characteristics and limitations
4. Identify specific applications where remote processing may be used as a tool for monitoring and research

Module No	Title	Detailed Content	Hours
1	**Introduction to remote sensing**	What is Remote Sensing (RS)? Characteristics/elements of RS systems, Electromagnetic Radiation Electromagnetic Spectrum, Polarization, Interactions with the Atmosphere (Absorption, Scattering: Rayleigh, Mie, Non selective, absorption), Radiation - Target interactions, Passive vs. Active Sensing, Basic Image processing concepts: Image as a matrix, B/W and Colour (RGB)	5
2	**Sensors**	Ground and Air, Satellite Characteristics: orbits, swaths, Spatial Resolution, Pixel Size (IFOV, resolution cell), Spectral, Radiometric, Temporal Resolution, Cameras and Aerial Photography, Multispectral and Hyperspectral Scanning, Thermal Imaging, Geometric Distortion, Different Satellites: All Weather Satellites, Land Observation, Marine Observation, LIDAR, FLIR, RADAR, Side looking Radar	10
3	**Microwave Remote Sensing**	Introduction, RADAR Basics, Viewing Geometry, RADAR Image Distortions, Target Interaction and Image Appearance, RADAR Image Properties, RADAR Polarimetry (Polarization, Signatures, Backscatter, Parameters Affecting Backscatter, Applications), Synthetic Aperture RADAR (SAR), Airborne and	10

		Spaceborne Radars. Comparison of Optical and Microwave Remote Sensing Techniques.	
4	**Image Transforms**	Visual Image Analysis (tone, shape, size, pattern, texture, shadow, and Association), Digital Image Processing steps (Pre-processing, Enhancement, Transformation and Classification), Contrast Enhancement: Global, Local Techniques, Filtering, Image Transformations: Arithmetic Operations (Subtraction, Spectral Ratio, NDVI, PCT, FT, Color, Hough Transforms)	8
5	**Image Classification and Analysis**	Visual Interpretation, Image Classification: Optimum band selection, Supervised learning techniques, Assessment of Classification Accuracy (Confusion or Error Matrix, Omission and Commission Error, Kappa Coefficient), Unsupervised techniques: K-means, ISODATA, Fuzzy C-means, Hierarchical clustering, Evaluation Techniques	8
6	**Applications of Remote Sensing**	Agriculture, Forestry, Land Cover/ Land Use Mapping, Water Resources, Snow and Glacier, Wetland Management, Oceans and Coastal, Soil Moisture	4

Text & Reference Books:

Textbooks:

1. **Fundamentals of Remote Sensing,** George Joseph, Universities Press; Second Edition, ISBN-10: 817371535, ISBN-13: 978-8173715358
2. **Remote Sensing: Models and Methods for Image Processing,** Robert A. Schowengerdt, Academic Press, Third Edition, ISBN-10: 8131203182, ISBN-13: 978-8131203187
3. **Remote Sensing and Image Interpretation,** Lillesand, Kiefer, Chipman, Wiley, Sixth Edition, ISBN-10: 8126532238, ISBN-13: 978-8126532230

References Books:

1. **Introduction to Microwave Remote Sensing, Iain H. Woodhouse, CRC Press, ISBN-10: 0415271231, ISBN-13: 978-0415271233**
2. **Digital Image Processing**, Rafael C. Gonzalez, Richard Eugene Woods, Prentice Hall, Third Edition, 2013, ISBN-13: 9789332518469
3. **Digital Image Processing**, S Jayaraman , S Esakkirajan, T Veerakumar, Mcgraw Hill Education, First Edition, 2009, ISBN-10: 0070144796, ISBN-13: 9780070144798

E-books

1. **A Canada Centre for Remote Sensing Remote Sensing Tutorial**
   https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/resource/tutor/fundam/pdf/fundamentals_e.pdf

2. **Fundamentals of Remote Sensing**

http://geography.huji.ac.il/personal/Noam%20Levin/1999-fundamentals-of-remote-sensing.pdf

3. **Principles of Remote Sensing – ITC**
   https://www.itc.nl/library/papers_2009/general/principlesremotesensing.pdf

4. **Principles of Remote Sensing---An introductory textbook**
   http://www.gdmc.nl/oosterom/PoRSHyperlinked.pdf

5. **The ASAR User Guide**
   https://earth.esa.int/handbooks/asar/toc.html

Open Source Software for Image Processing

1. https://earth.esa.int/web/polsarpro/download/version-5.0\
2. https://earth.esa.int/web/nest/downloads
3. http://www.lvc.ele.puc-rio.br/projects/interimage/
4. https://www.orfeo-toolbox.org/

Free Data available

1. **SAR Data:** https://www.asf.alaska.edu/sar-data/

2. **Optical Data**
   Bhuvan (ISRO): http://bhuvan.nrsc.gov.in/bhuvan_links.php
   LANDSAT: http://landsat.usgs.gov//Landsat_Search_and_Download.php

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Examination:

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Course Name: Embedded Communication Systems Design

Course Code: ET79

Category: Professional Elective-1 (Embedded & IoT Track)

Preamble:

To understand the concepts of embedded systems and its applications in Internet of Things.

Pre-requisites:

1. Microcontrollers
2. Digital Communication protocols.

Course Objectives:

On completion of this course, successful participants will be able to:

- Perform effectively as entry level Embedded Systems professionals.
- Develop and maintain applications written using Embedded C.
- Independently design and develop a hardware platform encompassing a microcontroller and peripherals

Course Outcomes:

Learner will be able to:

CO1: Understand the embedded concepts and design approach for embedded systems.
CO2: Understand the hardware and software trade off for design of embedded systems.
CO3: Use microcontroller boards and framework for design of embedded systems.
CO4: Apply standard communication protocols for design of embedded systems
CO5: Use muti core processor for design of embedded systems.
CO6: Design embedded system with RTOS.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module no.	Module Name	Content	No. of Hours
1	Overview of Product Design for Embedded Systems	Embedded systems, Need, design challenges, product survey, specifications of product need of hardware and software, partitioning of the design into its software and hardware components, iteration and refinement of the partitioning	8
2	Software and Hardware for Design	Trade-offs, custom single-purpose processors, general-purpose processors, memory, interfacing, design technology-hardware design, cost reduction, re-engineering, optimization, maintenance, validation and development, prototyping, turnkey product design	8
3	ARM Architecture and technologies for Embedded Systems	Embedded concepts, architecture of embedded systems, ARM architecture, Cortex-M3 basics, exceptions, instruction sets, NVIC, interrupt behaviour, Cortex-M3/M4 programming, memory protection unit and other Cortex-M3 features, STM32xxx ARM Cortex M3/M4 microcontroller memory and peripherals, development & debugging tools	9
4	Embedded Systems Communication and Security	Communication protocols for embedded systems, Embedded systems security and secured hardware structures, Communications security in embedded systems.	9
5	Multi core Architecture	Multi-Core architecture for embedded systems, Programming models for Multi-Core, Embedded Multi-Core processing for networking.	4
6	Open Source RTOS for System Design	Basics of RTOS: Real-time concepts, Hard Real time and Soft Real-time, differences between general purpose OS & RTOS, basic architecture of an RTOS, scheduling systems, interprocess communication, performance Matric in scheduling models, interrupt management in RTOS environment, memory management, file systems, I/O systems, advantage and disadvantage of RTOS. POSIX standards, RTOS issues – selecting a Real Time Operating System, RTOS comparative study.	7
Total			**45**

Recommended Online Courses:

1. Embedded Systems Programming on ARM Cortex-M3/M4 Processor: https://www.udemy.com/course/embedded-system-programming-on-arm-cortex-m3m4/
2. Master Microcontroller and Embedded Driver Development(MCU1): https://www.udemy.com/course/mastering-microcontroller-with-peripheral-driver-development/

Suggested List of Practicals:

1. Comparative study of customized microcontroller boards.
2. Interface output devices with ARM controller.
3. Interface input devices with ARM controller.
4. Implement serial communication using UART with ARM controller for embedded application.
5. Implement serial communication using SPI with ARM controller for embedded application.
6. Implement serial communication using I2C with ARM controller for embedded application.
7. Comparative study of security techniques for embedded application.
8. Implement security for embedded application.
9. Comparative study of RTOS for embedded application.
10. Comparative study of scheduling algorithms of RTOS.
11. Implement embedded application using RTOS.
12. Comparative study of multi core architecture and software framework
13. Mini Project based on design of embedded systems for communication based application.
14. Mini project based on design of embedded systems for Internet of Things (IoT) application.

Reference Books:

1. The Definitive Guide to the ARM Cortex-M3, Joseph Yiu, Second Edition, Elsevier Inc. 2010.
2. Andrew N Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide - Designing and Optimizing System Software", 2006, Elsevier.
3. Communicating Embedded Systems: Networks Applications, Francine Krief (Editor) February 2010, Wiley-ISTE.
4. Frank Vahid and Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley publication.
5. P Marwedel, "Embedded System Design", Springer publication.

Course Name: Sensor Technology MEMS & NEMS

Course Code: ET83

Category: Professional Elective-1 (VLSI Track)

Preamble:
This course Explore different MEMS Processing steps and modules. It also provides the knowledge of MEMS materials as per the application.

Pre-requisites:

1. Basic Electrical and Electronics Engineering. – Strongly Related
2. Electronic Devices and Circuits - Strongly Related.
3. Microelectronics- Strongly Related
4. Analog IC Design- Strongly Related

Course Outcomes:

Learner will be able to:
CO1: To provide knowledge of MEMS processing steps and processing modules
CO2: To provide knowledge of MEMS Materials with respect to applications.
CO3: To demonstrate the use of semiconductor based processing modules used in the fabrication of variety of sensors and actuators (e.g. pressure sensors, accelerometers, etc.) at the micro-scale
CO4: To provide an understanding of basic design and operation of MEMS sensors, actuators and structures.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module no.	Module Name	Content	No. of Hours
1	Introduction to MEMS	Introduction to MEMS, Comparison with Micro Electronics Technology, Real world examples (Air-Bag, DMD, Pressure Sensors), MEMS Challenges, MEMS Sensors in Internet of Things (IoT), Bio-medical applications	9
2	MEMS Materials and Their Properties	Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure Materials (eg. Si, SiO2, SiN, SiC, Cr, Au, Al, Ti, SU8, PMMA, Pt)	9
3	MEMS Sensors, Actuators and Structures	MEMS Sensing (Capacitive, Piezo electric Piezo resistive) Micro Actuation Techniques (Thermal, Piezo electric, Electro static, Shape Memory Alloys, LORENTZ FORCE ACTUATION), Micro Grippers, Micro Gears, Micro Motors, Micro Valves, Micro Pumps	9
4	MEMS Fab Processes	MEMS Processes & Process parameters: Bulk & Surface Micromachining, High Aspect Ratio Micro Machining (LIGA, Laser), X-Ray Lithography, Photolithography, PVD techniques, Wet, Dry, Plasma etching, DRIE, Etch Stop Techniques. Die, Wire & Wafer Bonding, Dicing, Packaging(with Metal	9
5	MEMS Devices	Architecture, working and basic behaviour of Cantilevers, Micro heaters, Accelerometers, Pressure Sensor types, Micromirrors in DMD, Inkjet printer-head. Steps involved in Fabricating above devices	6
6	MEMS Device Characterization	Piezo-resistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, & importance of these measurements in studying device behaviour .	3
Total			**45**

Text Books:

1. Tai Ran Hsu," MEMS and MICROSYSTEMS Design and Manufacture", 2nd Edition, McGraw-Hill, 2002.
2. N. Maluf, K Williams," An Introduction to Micro-electromechanical Systems Engineering", 2nd Edition, Artech House Inc, 2004.

Recommended Online Courses:

1. MEMS &MICROSYSTEM By Prof. Santiram Kal | IIT Kharagpur.

Reference Books:

1. Ville Kaajakari ," Practical MEMS ", Small Gear Publishing , 2009.

Course Name: Fundamentals of Machine Learning

Course Code: ET92T

Category: Professional Elective-1 (ML Track)

Preamble:
This course aims to provide necessary mathematical background to understand the development of supervised and unsupervised machine learning algorithms. Learners will be introduced to machine learning algorithms including regression, classification and clustering tasks.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Sound understanding of Linear Algebra, Vector Spaces, Probability Distributions, Random Variables, Statistical Techniques is mandatory
- Sound understanding and proficiency in Python Programming including handling and usage of Python Libraries like NumPy, Pandas, Matplotlib, Seaborn, SciPy is mandatory

Course Objectives:

- To understand the mathematical terminologies, probability and linear algebra used in ML algorithms.
- To apply Python programming skills for data cleansing operations.
- To create Regression models for target variable prediction tasks in machine learning.
- To create Classification models for target variable classification tasks in machine learning.
- To create Clustering models for unsupervised Machine Learning applications

Course Outcomes:

Student will be able to:

CO1: Understand the various probability and linear algebra usage for foundation of Machine Learning
CO2: Apply Python Programming structures for data cleaning operations
CO3: Create Regression ML models for target variable estimation operation
CO4: Create Classification ML models for target variable classification purpose
CO5: Create Clustering models for unsupervised ML applications

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head	ISA	MSA	ESE	Total (Passing @45% of total)
Theory	40	20	40	100
Lab	25	--	--	25

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 Machine Learning	Definition and importance of Machine Learning, Applications of Machine Learning, types of machine learning: Supervised Learning, Unsupervised Learning	2
2	Mathematical Foundations for ML	Basics of Linear Algebra: Vectors, Matrices, Vector Spaces, Vector Norms, Eigen Values, Eigen Vectors, Probability and statistics: Probability distributions-continuous and discrete, Conditional Probability, Baye's theorem, Expectation, variance, Central limit theorem	4
3	Data Preprocessing	Introduction to Data Preprocessing, Importance of Data Preprocessing, Data Cleaning operations – Handling missing values, removing duplicate data, handling outliers, Data Normalization and standardization techniques and its necessity, visualizing data distributions, correlation between variables, merging datasets, concatenating datasets, Data manipulation using Pandas	9
4	Feature Engineering	Imbalanced Data Handling, oversampling, under sampling, SMOTE techniques, correlation evaluation between feature variables, multicollinearity principle, concepts of bias and variance in datasets, variable selection (feature selection), Categorical encoding (label encoding, one-hot encoding), scaling of numerical data Principal Component Analysis technique (feature extraction)	10
5	Supervised Learning	Concept of supervised Machine Learning, supervised learning problems: Classification verses Regression,	10

		Linear Regression: Simple Linear Regression, Multiple Linear Regression, Evaluation of model performance: RMSE, R-squared, MAE, Classification algorithms: Logistic Regression, k-Nearest Neighbours (kNN), Naïve Bayes Classifier, Decision Tree Classifier and Regressor, Random Forest, Ensemble Techniques – Gradient Boosting (XGBoost), Support Vector Machines for classification and regression, Kernel methods for nonlinear SVM, model evaluation – cross validation techniques, bias-variance trade-off, confusion matrix, precision, recall and F1-score	
6	Unsupervised Learning	Concept of Unsupervised Machine learning, difference between supervised and unsupervised machine learning, Clustering Algorithms – K means clustering, applications and limitations, Density based clustering – DBSCAN algorithm, Gaussian Mixture Model algorithm, Case studies – Manufacturing and education datasets	10
Total			**45**

Textbooks:

1. Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Sheldon M Ross, Elsevier Publication
2. Handson Data Preprocessing in Python: Roy Jafari, Packt Publication, 2022
3. Machine Learning with Python: Theory & Implementation, Amin Zollanvari, Springer Publications

Reference Books:

1. Practical Machine Learning with Python, Sarkar Bali & Sharma, Apress Publication
2. Introduction to Machine Learning with Python, Andreas C. Muller, Sarah Guido, Oreilly Publication

Assessment:

1. **ISA (In-Semester-Assessment):** In semester assessment will carry total 40 marks. It will consist of 4 graded assignments based on modules – 3, 4, 5 and 6 (each carrying 10 marks). The assignments are self-study work and need to be completed by individual students separately. Every student will be submitting four completed assignments. ***These assignments should be different from each of the students. (No common problem solving).*** Students are encouraged to develop their own problem statements and devise a proper method / solution. Importance will be given to the concept understanding and applying it to solve the industrial problem using Python coding. ***Students are encouraged to take upon real industrial problem and not any dummy data model.***

A] Assignment 1:
Dataset Cleansing Operation. Data Wrangling Operation on sufficiently large real time data records.

B] Assignment 2:
Data preprocessing with feature selection and feature extraction principle on sufficiently large real time data records

C] Assignment 3:
Case study and its solution on supervised ML algorithm. Compare result with different ML algorithms

D] Assignment 4:
Case study and its solution on supervised ML algorithm. Compare result with different ML algorithms

2. **MSA (Mid-Semester-Assessment):** Mid Semester Assessment will consist of single mid semester internal theory test carrying 20 marks based on completion of minimum 2 chapters. This test will be common for all the students. ***Repeat examination will not be conducted.***

3. **ESE (End-Semester-Examination):** End Semester Examination will be conducted for total of 40 marks based on the completion of remaining modules post completion of mid semester examination or an entire syllabus. This test will be common for all the students.

Course Name: Fundamentals of Machine Learning

Course Code: ET92P

Category: Professional Elective-1 (ML Track)

Preamble:

This course aims to provide necessary mathematical background to understand the development of supervised and unsupervised machine learning algorithms. Learners will be introduced to machine learning algorithms including regression, classification and clustering tasks.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Sound understanding of Linear Algebra, Vector Spaces, Probability Distributions, Random Variables, Statistical Techniques is mandatory
- Sound understanding and proficiency in Python Programming including handling and usage of Python Libraries like NumPy, Pandas, Matplotlib, Seaborn, SciPy is mandatory

Course Objectives:

- To develop ML algorithm using Supervised learning approach
- To develop ML algorithm using unsupervised learning approach
- Creating labelled supervised data model with clustering approach
- To create hyper parameter tuning model for performance comparison different models
- To evaluate model performances using different statical metrics

Course Outcomes:

Student will be able to:

CO1: Apply supervised ML algorithm for prediction / estimation of target variable (regression)

CO2: Apply supervised ML algorithm for classification of target variable (classification)

CO3: Apply unsupervised ML algorithm for prediction / estimation of target variable (regression)

CO4: Apply unsupervised ML algorithm for classification of target variable (classification)

CO5: Apply segmentation technique using Clustering operation

Course Scheme:

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

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

Note – It is mandatory that, student must have prior sound knowledge of related mathematics and statistics and Python Programming (including handling libraries like NumPy, Pandas, Matplotlib, Seaborne, SciPy, ScikitLearn etc.) Laboratory session will comprise of three distinct methodologies:

1. Design of ML algorithm using Supervised algorithm for regression estimation
2. Design of ML algorithm using Supervised algorithm for classification
3. Design of ML algorithm using unsupervised algorithm for regression estimation
4. Design of ML algorithm using unsupervised algorithm for classification
5. Dimensionality reduction technique using Principal Component Analysis
6. Segmentation / clustering algorithm
7. Feature engineering operation – feature selection, feature extraction
8. Hyper Parameter tuning for different ML algorithms

Textbooks:

1. Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Sheldon M Ross, Elsevier Publication
2. Handson Data Preprocessing in Python: Roy Jafari, Packt Publication, 2022
3. Machine Learning with Python: Theory & Implementation, Amin Zollanvari, Springer Publications

Reference Books:

1. Practical Machine Learning with Python, Sarkar Bali & Sharma, Apress Publication
2. Introduction to Machine Learning with Python, Andreas C. Muller, Sarah Guido, Oreilly Publication

Assessment: In-Semester-Assessment (25 Marks)

1. ***All the students are required (mandatory) to be present in person during the laboratory conduction session. The laboratory session will only be conducted in offline (in presence mode) only as it involves actual measurement procedure with hands-on tasks.***
2. The ISA will consist of awarding marks for the complete, successful and in time submission of minimum 10 dually graded experiments shared commonly between all the students during the laboratory session.
3. ***Graded marks for 10 experiments will be converted to ISA marks of 25 (see the list of experiments above) Only one repeat session is allowed to cover up the missed lab session.***
4. Students will be awarded grade / or marks on each experiment based on his / her own contribution, showcasing the knowledge application skills, demonstrating measurement work, developing code / solution to the given problem and peer interaction. ***Student will lose the marks if he or she remains absent for the Laboratory Practical Session.***

Course Name: Cloud Computing and IoT

Course Code: ET93

Category: Professional Elective-2 (Embedded IoT Track)

Preamble:

This course enables learners to understand the use of cloud computing in Internet of things (IoT). The learner will be introduced to concepts of cloud computing like architecture of cloud systems. Further learner will be introduced to design principles of IoT applications. Learner will learn the advanced software engineering principles and methodologies for effective Software tools and development

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and Microcontroller
- Fundamentals of Embedded System Design

Course Objectives:

- To understand the concepts of cloud computing.
- To use IoT protocols for use in cloud based application.
- To understand cloud architecture.
- To understand security issues in cloud computing.
- To understand recent trends in cloud computing

Course Outcomes:

Student will be able to:

CO1: Understand the various concepts of cloud computing.
CO2: Apply different IoT protocols for cloud applications.
CO3: Understand cloud application architectures.
CO4: Apply security measures in cloud computing.
CO5: Understand concepts of fog computing.
CO6: Use recent trends in IoT and cloud computing applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head	ISA	MSA	ESE	Total (Passing @45% of total)
Theory	40	20	40	100
Lab	25	--	--	25

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	Cloud Architecture Basics	The Cloud -Hype cycle-metaphorical interpretation-cloud architecture standards and interoperability- Cloud types; IaaS, PaaS, SaaS. Benefits and challenges of cloud computing, public, private clouds community cloud, role of virtualization in enabling the cloud	9
2	IoT Networks	IoT network architecture, and wearable IoT networks, WLAN (Wireless Local Area Network), WPAN (Wireless Personal Area Network), and LPWAN (Low-Power Wide Area Network), WPAN (which include Bluetooth, ZigBee, 6LoWPAN, and IEEE 802.15.4 technology) and LPWAN (which include LoRa, UNB, Sigfox, and NB-IoT).	8
3	CLOUD APPLICATION ARCHITECTURES	Development environments for service development; Amazon, Azure, Google Appcloud platform in industry	9
4	Security in the Cloud	Security Overview – Cloud Security Challenges –Risk Management -Security Monitoring – Security Architecture Design – Data Security -Application Security – Virtual machine Security.	9
5	Introduction to fog computing:	Fog Computing and Internet of Things-Pros and Cons - Need and Reasons for Fog Computing- Fog Computing and Edge Computing	6
6	Trends in IoT and Cloud Computing	Recent Trends in IoT application and cloud computing – Case study	4
Total			**45**

Textbooks:

1. Reese, G. (2009). Cloud Application Architectures: Building Applications and Infrastructure in the Cloud. Sebastopol, CA: O'Reilly Media, Inc. (2009).
2. John Rhoton ,Cloud Computing Explained: Handbook for Enterprise Implementation 2013 edition, 2013, recursive press
3. RajkumarBuyya, Christian Vecchiola, S.ThamaraiSelvi,Mastering Cloud Computing: Foundations and Applications Programming,MorganKaufmann,,Elsevier publication, 2013
4. Thomas Erl, ZaighamMahmood, and Ricardo Puttini,Cloud Computing Concepts, Technology & Architecture, PRENTICE HALL,2013

Reference Books:

1. "IoT and Edge Computing for Architects" Perry Lea,"-second edition, Packt, March,2020.
2. "Secure Edge Computing: Applications, Techniques and Challenges", Mohiuddin Ahmed (Editor), Paul Haskell-Dowland (Editor), CRC press, first edition, August 2021.
3. Research Articles/Papers

Assessment:

4. **ISA (In-Semester-Assessment):** In semester assessment will carry total 40 marks. It will consist of graded assignments based on all modules **(**each carrying 10 marks). The assignments are self-study work and need to be completed by individual students separately. Students are encouraged to develop their own problem solution. Importance will be given to the concept understanding and applying it to solve the industrial problem using Python coding. ***Students are encouraged to take upon real industrial problem.***

5. **MSA (Mid-Semester-Assessment):** Mid Semester Assessment will consist of single mid semester internal theory test carrying 20 marks based on completion of minimum 2 chapters. This test will be common for all the students. ***Repeat examination will not be conducted.***

6. **ESE (End-Semester-Examination):** End Semester Examination will be conducted for total of 40 marks based on the completion of remaining modules post completion of mid semester examination or an entire syllabus. This test will be common for all the students.

Course Name: Analog Mixed signal circuit design.

Course Code: ET84

Category: Professional Elective (VLSI Track)

Preamble:

This course introduces students Importance of Mixed signal VLSI Design in the field of Electronics and telecommunication. Methodologies for analysis and designing of fundamental CMOS Mixed signal circuits.

Pre-requisites:

1. Basic Electrical and Electronics Engineering.
2. Electronics circuits and Devices.
3. Circuit Theory.
4. Microelectronics.
5. Digital VLSI Design.

Course Objectives:

- To understand the issues in designing and layouts of Mixed Integrated circuits.
- To understand the designing of various Integrated circuit biasing circuits.
- To understand the concept of Active load amplifier and its implementation.
- To understand the designing of two stage operational amplifier circuits.
- To understand the working concepts of various data converter circuits.

Course Outcomes:

Student will be able to:

1. Students will be able to **remember & understand** the trade-offs involved in Analog VLSI Circuits.
2. Students will be able to **analyse** building blocks of CMOS Analog VLSI circuits.
3. Students will be able to **evaluate** the values of different circuit components while design CMOS Analog VLSI circuits.
4. Students will be able to **create** a mixed signal system for a given specification.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	2

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	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	Active Load MOS Differential Amplifier:	Small Signal equivalent Analysis of MOS Active load Differential Amplifier. MOS Differential Amplifier with Cascode active load.	9
2	Design of MOS Operational Amplifiers	General consideration, one stage Op Amps, Two stage Op Amps, Gain Boosting, Input Range Limitation. Frequency Response and Compensation, Slew Rate	9
3	Noise:	Statistical Characteristics of Noise. Types of Noise Thermal and Flicker. Representation of Noise in circuits noise in common source amplifier stage. Noise in differential pairs. Noise Bandwidth.	9
4	Oscillators and Phase Locked Loops	General consideration, Ring oscillators,LC Oscillators,VCO,tunning range,tunning linearity. Mathematical Model of VCO. Simple PLL phase detector, Charge pump PLL'S Non ideal effects in PLL,Delay locked loops, application of PLL.Introduction to Switch capacitor circuits.	6
5	Data Converters	Analog versus digital discrete time signals, converting analog signals to data signals, sample and hold characteristics. DAC specifications, ADC specifications. Mixed signal layout issues, Floor planning, Power supply and ground issues, other interconnect consideration.	6
6	Data Converter Architectures	DAC architectures, digital input code, resistors string, R-2R ladder networks, current steering, charge scaling DACs, Cyclic DAC, pipeline DAC,	6

		ADC architectures, flash, 2-step flash ADC, pipeline ADC, integrating ADC, and successive approximation ADC	
Total			**45**

Guidelines to conduct practical sessions:

1. Practical's will be conducted using Software tools.

Students must design the circuit for given problem and then simulate using software tools like LT-SPICE, CADENCE and verify the results.

Suggested List of Practical's.

Practical No.	Title of the Regular Experiments
1	Implementing MOSFET as a sampling switch
2	Implementing and simulating passive load differential amplifier using MOSFET.
3	Implementing and simulating ACTIVE load differential amplifier using MOSFET
4	Implementing and simulating Two stage operational amplifier using MOSFET
5	Designing and implementing MOS CS amplifier Finding its Noise Figure.
6	Designing and implementing MOS CG amplifier and Finding its Noise figure.
7	Designing and implementing differential amplifier and finding its Noise figure.

Textbooks:

1. Design of Analog CMOS Integrated Circuits,B. Razavi McGraw Hill
2. CMOS Circuit Design, Layout, Stimulation Harry W. Li and David E Boyce PHI Edn
3. CMOS Analog Circuit Design",P.E.Allen and D R Holberg Oxford University Press
4. Analysis and design of Analog Integrated Circuits Gray, Meyer, Lewis and Hurst, Willey International.

Reference Books:

1. Analysis and design of Analog Integrated Circuits, Gray, Meyer, Lewis and Hurst Willey International, 4th Edition, 2002

Data Warehousing and Data Mining

Course Code – ET94

Category: Professional Elective-2 (ML Track)

Objective

- To understand the principles of Data warehousing and Data Mining.
- To be familiar with the Data warehouse architecture and its Implementation.
- To know the Architecture of a Data Mining system.
- To understand the various Data preprocessing Methods.
- To perform classification and prediction of data.

Course Outcomes

1. Understand the functionality of the various data mining and data warehousing component
2. Select appropriate of various data mining and data warehousing models
3. Apply acquired knowledge for understanding data and select suitable methods for data analysis
4. Apply different classification and clustering models

UNIT I

Data Warehousing and Business Analysis: - Data warehousing Components –Building a Data warehouse –Data Warehouse Architecture – DBMS Schemas for Decision Support – Data Extraction, Cleanup, and Transformation Tools –Metadata – reporting – Query tools and Applications – Online Analytical Processing (OLAP) – OLAP and Multidimensional Data Analysis.

UNIT II

Data Mining: - Data Mining Functionalities – Data Preprocessing – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization and Concept Hierarchy Generation- Architecture of A Typical Data Mining Systems- Classification of Data Mining Systems.
Association Rule Mining: - Efficient and Scalable Frequent Item set Mining Methods – Mining Various Kinds of Association Rules – Association Mining to Correlation Analysis – Constraint-Based Association Mining.

UNIT III

Classification and Prediction: - Issues Regarding Classification and Prediction – Classification by Decision Tree Introduction – Bayesian Classification – Rule Based Classification – Classification by Back propagation – Support Vector Machines – Associative Classification – Lazy Learners – Other Classification Methods – Prediction – Accuracy and Error Measures – Evaluating the Accuracy of a Classifier or Predictor – Ensemble Methods – Model Section.

UNIT IV

Cluster Analysis: - Types of Data in Cluster Analysis – A Categorization of Major Clustering Methods – Partitioning Methods – Hierarchical methods – Density-Based Methods – Grid-Based Methods – Model-Based Clustering Methods – Clustering High-Dimensional Data – Constraint-Based Cluster Analysis – Outlier Analysis.

UNIT V

Spatial, Text and Web Data Mining, Applications and Trends in Data Mining: Financial Data analysis, Retail Industry, Biological data analysis, Intrusion Detection, Telecommunication Industry

Text Book

1. Jiawei Han, Micheline Kamber and Jian Pei"Data Mining Concepts and Techniques", Third Edition, Elsevier, 2011.

Reference Books

1. Alex Berson and Stephen J. Smith "Data Warehousing, Data Mining & OLAP", Tata McGraw – Hill Edition, Tenth Reprint 2007.
2. K.P. Soman, Shyam Diwakar and V. Ajay "Insight into Data mining Theory and Practice", Easter Economy Edition, Prentice Hall of India, 2006.
3. G. K. Gupta "Introduction to Data Mining with Case Studies", Easter Economy Edition, Prentice Hall of India, 2006.
4. Pang-Ning Tan, Michael Steinbach and Vipin Kumar "Introduction to Data Mining", Pearson Education, 2007.

Course Name: Teaching Pedagogy and Educational Technology

Course Code: To be decided

Category: Open Elective

Preamble:

The rapid progress of the Internet and allied technologies, emphasis on outcome-based education, the importance of participative learning, and changing student expectations demand rapid development of engineering faculty teaching competencies. Further, the growing heterogeneous capabilities and motivations of students are giving rise to more diverse learning needs, which require changes in the existing paradigms of engineering education. Today, faculty members must adopt more flexible and student-centric paradigms and focus on developing students' attributes. We propose a four-credit course on teaching pedagogy and Educational Technology to train upcoming or budding faculty members in new and impactful education techniques.

Pre-requisites: N/A

Course Outcome:

Students will be able to :

1) Understand university teaching and its requirements.
2) Apply the different teaching strategies and develop their lesson plan.
3) Apply different ICT tools in teaching.
4) Apply different Assessment methodologies for effective education.
5) Develop their MOOC.
6) Apply gamification to education courses.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical/Home Assignment	Theory	Practical/Homework
3	2	3	1

Examination Scheme:

ISA	MSE	ESE	Practical/Homework	Total
20	30	50	50	150

Practical/Homework:

50 Marks = where students need to develop their course for 1 or 2 credits. This session will be conducted in workshop mode and as a home assignment.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	University Teaching	What is university teaching, and how is it different from other teaching? What are the various theories/schools of thought for Teaching? Different Taxonomies and their Applications. What is education accreditation? NEP 2020	10
2	Teaching Leadership and Strategies	Developing Lesson Plans, Setting Labs/Practicals, PBL, Developing *Course Outcomes* of a subject, Think Pair Share Flipped Classroom, Collaborative learning, TBL, etc. Career path for teaching and mentoring.	8
3	ICT Tools	Digital Teaching Techniques, Generative AI tools, Digital lab journal alternative to lab notebook, Plicker, Crossword Mobile test, Beyond classroom activities, simulation tools, open-source tools, etc.	6
4	Assessment Methods	Formative and summative assessments, Evaluation Models and Different Types of Examinations, setting up surveys, setting rubrics, designing assessment methods, Festival of examination,etc.	6
5	Designing MOOC	Introduction to MOOC, Elements of MOOC, Development of MOOC-tools,setting up a MOOC using Moodle, Develop your Open Educational Resources (OERs).	6
6	Gamification	What are gamifications? Types of games, designing principles of games, use of games in education.	4
Total			**40**

Guidelines to conduct practical/home assignment sessions:

2. The capstone project will be conducted by an individual or a group of two students.
3. To encourage project-based learning in the curriculum, students may select one of the subjects of their choice after a review and approval by the subject in charge.
4. Each team will do a rigorous literature survey of the MOOC Subject by reading and understanding at least 3-5 research papers from current good quality national/international journals/conferences. (Papers selected must be indexed by Scopus/IEEE/Springer/ACM etc.). The list of papers surveyed must be clearly documented.
5. The project assessment for term work will be done at least twice a semester by giving a presentation to the faculty in charge or a panel of expert members.

Deliverables of the capstone project by the student or the group:

Sr. No	Deliverables	Hours in Practical Session	Hours as a home assignment
1	A report summarizing the findings of the literature survey.	2	5
2	Content Development	2	5
3	Preparing Assessment and Other Reading Material	2	5
4	Final Deployment of the Course	2	10
5	Detailed synopsis of the implemented MOOC	2	5
Total		**10**	**30**

Skill Set (H, M, L)

1. Building your course (H)
2. Learning different tools (H)
3. Analysis of the Course and Feedback (M)

Tool Set

1. ICT
2. Moodle
3. Assessment/Feedback/Survey

Module Mapping

Module	Skill Set	Tool Set
Module 1	1,2	-
Module 2	1,2	-
Module 3	1.2,3	1,2,3
Module 4	1,2,3	1,2,3
Module 5	1,2,3	1,2,3
Module 6	2,3	1,3

Recommended Online Courses:

- IITBombayX Courses: https://courses.iitbombayx.in/dashboard
- University Teaching by The University of Hong Kong, Coursera.
- Assessment in Higher Education by Erasmus University Rotterdam, Coursera.

Reference Books:

1. "The Cambridge Handbook of the Learning Sciences" (2nd Edition) edited by R. Keith Sawyer. Publisher: Cambridge University Press, 2014 ISBN: 978-1107626577
2. "Design for How People Learn" by Julie Dirksen. Publisher: New Riders, 2nd Edition, 2015, ISBN: 978-0134211282
3. "E-Learning by Design" by William Horton. Publisher: Wiley, 2nd Edition, 2011 ISBN: 978-0470900024
4. "Integrating Technology in the Classroom: Tools to Meet the Need of Every Student" by Boni Hamilton. Publisher: International Society for Technology in Education, 2015,ISBN: 978-1564843642
5. "The SAGE Handbook of Digital Technology Research" edited by Sara Price, Carey Jewitt, and Barry Brown.Publisher: SAGE Publications Ltd, 2013,ISBN: 978-1446200476.

Note: This list, while comprehensive, is not exhaustive. Educational Technology is broad and constantly evolving, with new research, theories, and technologies emerging regularly. These texts provide a strong foundation, but engaging with current journals, conferences, and professional networks is essential for staying up to date.

Course Name: Research Methodology

Course Code: OE07

Category: Open Elective

Preamble:

This course is to make the students understand the importance of research and various methods that researcher used to investigate problems. The course will also help the students to make meaningful decisions.

Pre-requisites:

Quantitative Techniques – Strongly Related

Operations and production management - Strongly Related

Economics– Weakly Related

Course Outcome:

1. Understand the importance of research and various methods that researcher used to investigate problems.
2. Apply Modern Analytical tools for Business Management Decisions.
3. Derive strategies from the research.
4. Understand the challenges in collecting the data collection and analysis.
5. Interpret the data to make meaningful decisions.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module	Detailed Content	Hours
1	**Introduction and Basic Research Concepts** • Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle.Research methods vs Methodology • Need of Research in Business and Social Sciences	10

	• Objectives of Research • Issues and Problems in Research Characteristics of Research: Systematic, Valid, Verifiable, Empiricaland Critical	
2	**Types of Research** • Basic Research • Applied Research • Descriptive Research • Analytical Research • Empirical Research • Qualitative and Quantitative Approaches	10
3	**Research Design and Sample Design** • Research Design – Meaning, Types and Significance • Sample Design – Meaning and Significance Essentials of agood sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	12
4	**Research Methodology** • Meaning of Research Methodology	12
	• 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 Preparation of Research Report	
5	**Formulating Research Problem** • Considerations: Relevance, Interest, Data Availability, Choiceof data, Analysis of data, Generalization and Interpretation of analysis	08
6	**Outcome of Research** • Preparation of the report on conclusion reached • Validity Testing & Ethical Issues Suggestions and Recommendation	08
	Total	**60**

Textbooks and References:

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.

Detailed Syllabus of First Year Semester - II

Course Name: Advanced Digital Signal Processing

Course Code: ET73

Category: Core

Pre-requisites:

1. Signals and Systems – Strongly Related
2. Digital Signal Processing – Strongly Related
3. Mathematical Concepts like Vector Spaces, Probability, and random processes- Strongly Related
4. Linear Vector Spaces – Weakly Related

Course Objectives:

At the completion of this course, the learner should have in depth knowledge of processing digital signals.

Course Outcomes:

Learner will be able to:

CO1: Understand the basics of analysing discrete random signals and its characterization
CO2: Understand linear predictors and implementation using lattice structures
CO3: Understand Weiner filtering
CO4: Understand the working mechanism of adaptive signal processing
CO5: Understand the implementation of adaptive filtering using LMS and RLS algorithms

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Discrete random process	1. Concept of Random Process 2. Concept of Discrete random process and its characteristics 3. Characterization of white noise random process Innovation Process	4
2	Linear prediction and Optimum filtering	1. Forward and Backward linear Predictions 2. Solution of the Normal equations 3. AR, MA and ARMA models Lattice and Lattice-Ladder structures	6
3	Weiner Filtering	1. Types of Estimations 2. Optimization methods 3. FIR and IIR Weiner filters Non-Causal Wiener Filters	9
4	Adaptive systems	1. Concept of adaptive filtering 2. Linear Adaptive combiner Applications of Adaptive filters	9
5	Least Mena Square (LMS)	1. Error Criterion 2. LMS Algorithm 3. Related Stochastic Gradient Algorithm Properties of LMS	9
6	Root Least square (RLS)	1. RLS Algorithm 2. The LDU decomposition Factorization and square root Algorithm 3. Fast RLS Algorithm Properties of RLS Algorithm	8
Total			**45**

Recommended Online Courses:

1. https://nptel.ac.in/courses/117/105/117105075/
2. https://www.coursera.org/lecture/dsp2/2-3-2-a-optimal-least-squares-7FBnV

Reference Books:

1. Oppenheim A., Schafer R., Buck J., "Discrete Time Signal Processing", 2nd Edition, Pearson Education.
2. Proakis J., Manolakis D., "Digital Signal Processing", 4th Edition, Pearson Education.
3. Simon Haykin, Adaptive Filter Theory, 2nd Edition, John Wiley
4. A. H. Sayed, Adaptive filters,1st Edition, Wiley Learner.

Course Name: OFDM and MIMO Technology

Course Code: ET75

Category: Core

Preamble:

This course introduces the fundamental issues, concepts, and design principles in "orthogonal frequency-division multiplexing" (OFDM) communications – modulation, demodulation, synchronization, peak-to-average power ratio (PAPR) reduction. This course also introduces the fundamental issues, concepts, and design principles in "multiple-input multiple-output" (MIMO) wireless communications – MIMO channel model, antenna diversity, space-time coding, MIMO detection algorithms.

Pre - requisites:

1. Digital Communications – Strongly Related
2. Digital Signal Processing- Strongly Related
3. Probability– Weakly Related
4. Linear Systems- Weakly Related

Course Objectives:

The main objective of the course is to

- To make learners familiar with fundamentals of wireless communication systems.
- To understand the diversity and spatial multiplexing phenomenon in MIMO system.
- To understand the receiver system design for MIMO.
- To become familiar with OFDM and MIMO-OFDM systems.

Course Outcomes:

Learner will be able to:

CO1: To understand OFDM's transceiver architecture.
CO2: To understand the problem of PAPR and how to reduce the PAPR.
CO3: To understand how the OFDM receiver performs synchronization and the adverse effects of mis-synchronization.
CO4: To understand MIMO channel models and space-time coding.
CO5: To understand the concept and methods of diversity reception.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	OFDM Basics	Multi-carrier transmission; OFDM modulation & demodulation, BER; coded-OFDM; Orthogonal frequency-division multiple-access (OFDMA).	9
2	OFDM Synchronization	Effect/estimation of symbol-time offset (STO); Effect/estimation of carrier-frequency offset (CFO); Effect/compensation of sampling clock offset (SCO).	9
3	Peak-to-Average Power Ratio Reduction (PAPRR)	Distribution of OFDM-signal amplitude; PAPR & oversampling; Mitigation methods: clipping & filtering, selective mapping (SLM), partial transmit sequence (PTS), tone reservation (TR), tone injection (TI), etc.	9
4	Multiple-Input Multiple-Output (MIMO) Channel Models	Small-scale vs. large-scale fading; time-dispersive vs. frequency-dispersive fading; Spatial correlation.	9
5	Antennas Diversity	Receive-antenna diversity; Transmit-antenna diversity.	4
6	Spatially Multiplexed MIMO Systems	Space-time Coding, Detection for Spatially Multiplexed MIMO Systems	5
Total			**45**

Suggested List of Value-Added Home Assignments:

1. Reviewing Literature in the form of a technical paper based on the capstone project.
2. Novel technical paper writing based on the capstone project.

Suggested List of Practicals:

1. Inter Carrier Interference (ICI) mitigation in OFDM system.
2. Study and analysis of peak to average power ratio (PAPR) reduction schemes in OFDM system
3. Study and analysis of peak to average power ratio (PAPR) using SC-FDMA
4. Channel estimation schemes for OFDM system

5. Study and analysis of beamforming schemes for MIMO system
6. Study and analysis of diversity schemes for MIMO system
7. Implementation of SFBC-OFDM
8. Implementation of antenna selection schemes for MIMO system
9. Study and analysis of channel estimation schemes for MIMO system
10. Estimation of angle of arrivals in MIMO system

Recommended Online Courses:

1. Principles of Modern CDMA MIMO OFDM Wireless Communications Offered by IIT Kanpur – https://onlinecourses.nptel.ac.in/noc19_ee49/preview
2. Introduction to Wireless Communications offered by Yasir Ahmed on Udemy - https://www.udemy.com/course/introduction-to-wireless-communications/
3. Matlab course for wireless communication engineering offered by Khaled Ramadan on Udemy- https://www.udemy.com/course/matlab-course-for-wireless-communication-engineering/

Reference Books:

1. MIMO-OFDM Wireless Communications with MATLAB , by Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , Wiley, 2010, ISBN: 978-0-470-82561-7
2. Mohinder Janakiram, "Space time Processing and MIMO systems", Artech House, First Edition, 2004
3. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2008.
4. Hamid Jafarkhani, "Space Time coding-Theory and Practice", Cambridge University Press, First Edition, 2005.
5. Branka Vucetic, Jinhong Yuan, "Space Time coding", John Wiley and Sons, First Edition, 2003.
6. Andrea Goldsmith, "Wireless Communication", Cambridge University Press, First Edition. 2005.
7. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

Course Name: Smart Sensors and Internet of Things

Course Code: ET81

Category: Professional Elective-3 (Embedded & IoT Track)

Preamble:

In this course, the important sensors, associated interface electronics, signal conditioning, technology of smart sensors and IOT for the measurement and monitoring of vital environmental parameters will be studied.

Pre-requisites:

Applied Physics, Embedded System, Sensor Technology

Course objectives:

- The objective of this course is to Select the right sensor for a given application.
- To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterised, and analysed..
- Introduce evolution of internet technology and need for IoT.
- Discuss on IoT reference layer and various protocols and software
- Evaluate the wireless technologies used in IoT.

Course Outcomes:

Learner will be able to:

CO1: Create analytical design and development solutions for sensors

CO2: Select appropriate sensors for the given application development.

CO3: Evaluate performance characteristics of different types of sensors

CO4: Design and develop IoT based sensor systems

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Sensor characteristics	Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal	8
2	Physical Principle of Sensing	Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer, Optics, Fiber optics and waveguides	8
3	Sensor Interface and Applications	Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits. Case Studies: Inertial Sensors (Accelerometer & gyroscope), Healthcare Sensors (Glucometer, ECG & MRI), Smart building Sensors (Smoke & occupancy sensors)	8
4	Introduction to IoT	Introduction to Internet of Things: Characteristics of IoT, Design principles of IoT, IoT Architecture and Protocols, Enabling Technologies for IoT, IoT levels and IoT vs M2M.IoT Design Methodology: Design methodology, Challenges in IoT Design, IoT SystemManagement, IoT Servers..Basics of Arduino: Introduction to Arduino, Arduino IDE, Basic Commands for Arduino, Connecting LEDs with Arduino, Connecting LCD with Arduino.	8
5	IoT point to point communication technologies	IoT Communication Pattern, IoT protocol Architecture, Selection of Wireless technologies (6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA,Lifi,Wifi)	7

6	IoT application and its Variants	Case studies: IoT for smart cities, health care, agriculture, smart meters.M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0,IoT standards.	6
Total			**45**

Suggested list of Practicals:

1. Implementation of Signal Conditioning Circuits
2. Sensor interfacing using off-the-shelf components.
3. Performance Analysis of Optical Link with Different Detectors
4. Performance Analysis of Soliton Communication System
5. Effect of cross phase modulation on WDM system
6. Mitigation of Four wave mixing by NZ-DSF fiber
7. Performance Analysis of Optical Amplifier
8. Performance Analysis of DWDM System

Text Books:

1. Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.
2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1 st Edition, Wiley.
3. S. M. Sze, (1994), Semiconductor Sensors, 1 st Edition, Wiley.
4. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016.
5. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Aves and, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014

Reference Books:

1. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
2. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
3. John G Webster, "Measurement, Instrumentation and sensor Handbook", 2017, 2nd edition, CRC Press, Florida.

Course Name: VLSI Signal Processing.

Course Code: ET85

Category: Professional Elective-3 (VLSI Track)

Preamble:

This course Explore different Digital Signal Processor (DSP) architectures and to design systems using Programmable DSPs. Interface of memory and peripherals to a DSP; and acquire knowledge on different codec implemented on DSP.

Pre-requisites:

1. Basic Electrical and Electronics Engineering.
2. Electronic Devices and Circuits.
3. Digital System Design.
4. Digital VLSI Design.
5. Microcontrollers.
6. Digital Signal Processing.

Course Objectives:

- To understand the Architecture of Processors used in signal processing.
- To understand the design of various ALUS used in Digital Processors.
- To understand the concept of Memory designing and allocation for given application.
- To understand the concept of CODEC.

Course Outcomes:

Student will be able to:

1. Identify and use specific Digital Signal Processor for various applications
2. Design a system using programmable DSP.
3. Implement pipelining techniques to improve system performance.
4. Design involving memory and other interfaces to DSP.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	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	DSP Integrated Circuits and VLSI Technologies	Standard digital signal processors - Application specific ICs for DSP - DSP systems - DSP system design - Integrated circuit design.	9
2	Architectures for programmable	Basic Architectural Features DSP Computational Building Blocks Bus Architecture and Memory - Data Addressing Capabilities - Address Generation Unit - Programmability and Program Execution - Features for External Interfacing	9
3	Execution Control and Pipelining	Hardware looping – Interrupts – Stacks - Relative Branch support - Pipelining and Performance - Pipeline Depth – Interlocking - Branching effects - Interrupt effects - Pipeline Programming models.	9
4	Synthesis of DSP Architectures	Top-Down approach to DSP LSI - Circuit Synthesis - High Performance Data conversion Techniques - LSI Algorithms and Architectures - Hierarchical Design of Processor Arrays - Systolic Arrays - Stack Filters - Wave-front Array Processors	6
5	Interfacing Memory and I/O to DSP Processors	External bus interfacing signals Memory interface Parallel I/O interface Programmed I/O Interrupts and I/O -Direct memory access (DMA) A Multichannel buffered serial port (McBSP) - McBSP Programming.	6
6	Interfacing CODEC	CODEC interface circuit - CODEC programming - A CODEC-DSP interface example	6
Total			**45**

Guidelines to conduct practical sessions:

6. Practical's will be conducted by giving the Mini-Project to the Students.

Deliverables of the capstone project by the student:

Sr No	Deliverables
1	A report summarizing the problem findings.
2	Analysis and designing the hardware for the given problem
3	Detailed plan for execution of the project including the objectives and the scope.
4	Final repository of the project implementation.
5	Detailed synopsis of the implemented project.

Suggested List of Mini-Projects.

1. Image Compression algorithm implementation in Programmable DSP.
2. Image processing algorithm implementations on FPGA.
3. Turbo Decoder implementation.
4. CORDIC Algorithm implementation in PDSP/FPGA/ASIC flow.
5. Improved Adaptive filters.
6. Improved Median filters.

Textbooks:

1. DSP Integrated Circuits Lars Wan hammer Academic press, New York 2011
2. DSP Processor Fundamentals, Architectures & Features, Phil Lapsley, Jeff Bier, Amit Shoham, Edward A. Lee, Wiley-IEEE Press, First Edition,2011

Reference Books:

1. Architectures for Digital signal processing,Peter Pirsch, Wiley India, 2010

Course Name: Industrial Data Analytics & Optimization

Course Code: ET97

Category: Professional Elective-3 (ML Track)

Preamble:
This course introduces learners to understand the process of collecting, analysing, and using the data taken from industrial operations. The learner will be introduced to different types of Statistical modelling techniques and programming algorithms used for industrial processes and gain better understanding of industrial operations and optimizations for improved business decision making capabilities.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Sound understanding of Linear Algebra, Vector Spaces, Probability Distributions, Random Variables, Statistical Techniques is mandatory
- Sound understanding and proficiency in Python Programming including handling and usage of Python Libraries like NumPy, Pandas, Matplotlib, Seaborn, SciPy is mandatory

Course Objectives:

- To understand the terminologies used in industrial operation and manufacturing processes.
- To gain proficiency using Python programming for data collection, analysis and visualization.
- To apply analytical techniques and Machine Learning principles to solve industrial problems.
- To evaluate industrial process capability and capacity estimates.
- To create data model using statistical and algorithms for optimization purpose.

Course Outcomes:

Student will be able to:

CO1: Understand the various terminologies used in industrial processes
CO2: Apply statistical analysis & python programming to investigate industrial operations.
CO3: Analyse the industrial measurement systems and process capability.
CO4: Evaluate & optimize performance of industrial operations with algorithms.
CO5: Create solutions to solve industrial data problems and enable improved business decisions.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head	ISA	MSA	ESE	Total (Passing @45% of total)
Theory	40	20	40	100
Lab	25	--	--	25

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 Industrial Analytics	Overview of Industrial analytics, importance of data in industries and applications, terminologies – measurement system analysis, process capability, capacity planning, Root Cause Analysis, Descriptive, Predictive and Prescriptive Analytics, Business decisions and modelling	4
2	Statistical methods with Python	Overview of statistical methods, Python for Exploratory Data Analysis, Data manipulation and visualization using NumPy, Pandas, Matplotlib, Seaborn Libraries, Measures of Central Tendencies, Measures of Dispersion, Concept of Sample and Population, Central Limit Theorem, Discrete and Continuous Probability Distributions: Binomial, Poisson, Normal, Probability Mass Function and Probability Density Function, Statistical Inference: Hypothesis Testing, significance of p-value, Confidence intervals, alpha value, Type-I & Type II errors, Tests for means, variance and proportions, Z Test, t-Test, proportion test, variance test, ANOVA, Goodness of Fit Test, Contingency Tables	10

3	Measurement System Analysis and Process Capability	Measurement System Basic Concepts: True & Reference values, Resolution, Accuracy, Precision, Type 1 Gauge Study, Run charts, Linearity and Bias, Gauge R & R Study, Attribute Analysis, Kappa & Kendall's coefficients, Statistical Process Control (SPC), Pareto Analysis, Pivot Tables, Control charting – X bar & R chart, X bar & S chart, Individual X and moving range charts, P, NP, C and U charts, interpretation of control charts, manufacturing process development, skew and Kurtosis in data, process capability indices – Pp & Ppk, Cp & Cpk and their interpretation, measures of capacity, capacity metrics, Bottleneck analysis (industrial case study), single & Multiple part aggregations, Overall equipment effectiveness (OEE modelling – case study)	9
4	Machine Learning for Manufacturing Processes	Decision Trees, Overfitting, Kmeans, Centroid Visualizations, Regression Analysis, KNN, Grid Search, Regularization, Classification, Logistic Regression, Confusion Matrix, ROC curves, Supply Chain Analysis (SCA) – segmentation techniques, Forecasting methods, Time series modelling, Inventory simulations, RFM Analysis	10
5	Optimization Techniques in Industrial Operations	Introduction to Optimization, Mathematical formulation of problem statement, modelling – variables, objective functions, parameters, constraints, Linear Programming – Pyomo Platform, GLPK solver, Non-Linear Programming – Pyomo Platform, IPOPT solver, Transportation problem, Production Planning, Production Scheduling, Multi Product Optimization	6
6	Business Intelligence & Analytics	Introduction to Business Intelligence Analytics (BIA), drivers of BIA, architecture of BIA, Descriptive analytics & visualization, Customer Analytics, Survival Analysis, Customer Lifetime Value, Case study	6
Total			**45**

Textbooks:

1. Douglas C. Montgomery, "Introduction to Statistical Quality Control", 7th Edition. Wiley Publication (For module-1, Chapter- 1, 2 and for module-2 & 3, Chapter- 3, 4, 6, 7, 8)
2. Amin Zollanvari, "Machine Learning with Python Theory & Implementation", 1st Edition, Springer Publication (For module-4, Chapter-4, 5, 6 & 7)
3. Hamdy A. Taha, "Operation Research an Introduction", 8th Edition, Pearson, PHI (For module-5)
4. Han J, Pei J, Tong H, "Data Mining Concepts & Techniques", 4th Edition, Elsevier, New Delhi (For module-6, Chapters- 1 & 4)

Reference Books:

1. Peihua Qiu, "Introduction to Statistical Process Control", CRC Press
2. Sheldon M. Ross, "Introduction to Probability & Statistics for Engineers & Scientists", 5th Edition, Elsevier
3. D. Sarkar, Raghav Bali, Tushar Sharma, "Practical Machine Learning with Python- A Problem Solver Guide to Building Real World Intelligent Systems", Apress Publication
4. J. K. Sharma, "Operation Research: Theory & Applications", 6th Edition, Trinity Press

Assessment:

1. **ISA (In-Semester-Assessment):** In semester assessment will carry total 40 marks. It will consist of 4 graded assignments based on modules – 2, 3, 4 and 5 (each carrying 10 marks). The assignments are self-study work and need to be completed by individual students separately. Every student will be submitting four completed assignments. ***These assignments should be different from each of the students. (No common problem solving).*** Students are encouraged to develop their own problem statements and devise a proper method / solution. Importance will be given to the concept understanding and applying it to solve the industrial problem using Python coding. ***Students are encouraged to take upon real industrial problem and not any dummy data model.***

   A] Assignment 1:
   Industrial Problem based on Measurement System Analysis and Process Capability studies

   B] Assignment 2:
   Industrial Problem Solution design based on Classification, Regression, Supply Chain modelling, Inventory control, Time Series forecasting (any one)

   C] Assignment 3:
   Industrial Problem Solution design based on Optimization Techniques including Linear Programming, Non-Linear Programming (any one)

   D] Assignment 4:
   Business Modelling Solution based on Customer Analytics, Survival Analysis, Customer Life Time Value, Trend Analysis etc. (any one)

2. **MSA (Mid-Semester-Assessment):** Mid Semester Assessment will consist of single mid semester internal theory test carrying 20 marks based on completion of minimum 2 chapters. This test will be common for all the students. ***Repeat examination will not be conducted.***

3. **ESE (End-Semester-Examination):** End Semester Examination will be conducted for total of 40 marks based on the completion of remaining modules post completion of mid semester examination or an entire syllabus. This test will be common for all the students.

Course Name: Industrial Data Analytics & Optimization Lab

Course Code: ET97P

Category: Professional Elective-3 (ML Track)

Preamble:

This lab course work will enable students to develop analytical solutions to the real time industrial problems targeted to manufacturing processes and operations. The lab course focuses on learner's critical thinking capability and applying the Python programming skills to design mathematical models with formulation, analyze the given industrial problems and devise the optimized solution in order to enable improved decision-making capabilities in business operations. This lab course will be exclusively designed on the real time case studies taken from different manufacturing industries like electrical, electronics, chemical, machine tool, material handling etc.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Sound understanding of Linear Algebra, Vector Spaces, Probability Distributions, Random Variables, Statistical Techniques is mandatory
- Sound understanding and proficiency in Python Programming including handling and usage of Python Libraries like NumPy, Pandas, Matplotlib, Seaborn, SciPy is mandatory

Course Objectives:

- To understand industrial manufacturing terminologies and definitions of measurement systems
- To apply the knowledge of measurement metrics in measurement operations
- To develop statistical techniques to gain insights of the industrial data for analysis purpose
- To analyze industrial processes for stability and capabilities.
- To evaluate performances of different ML algorithms applied to industrial operations
- To enable improved decision making in business operations with the help of data analytics techniques

Course Outcomes:

Student will be able to:

CO1: Remember and identify correct metric for the measurement of industrial system and operations

CO2: Apply statistical methods to evaluate the performance of industrial measurement systems

CO3: Implement machine learning model for devising a solution to industrial problems with regression and classification

CO4: Design an optimized solution for the industrial problems using Linear, Nonlinear programming

concepts

CO5: Create meaningful insights, findings & observations from the industrial data through analysis to enable improved decision-making capability for business operations

Course Scheme:

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

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

Note – It is mandatory that, student must have prior sound knowledge of related mathematics and statistics and Python Programming (including handling libraries like NumPy, Pandas, Matplotlib, Seaborne, SciPy, ScikitLearn etc.) Laboratory session will comprise of three distinct methodologies:

a. Understanding of industrial manufacturing metric terminologies through hand-on experimentation on different measurement tasks
b. Developing mathematical model (formulation) in order to enable individual to solve the industrial problem
c. Development of code using Python programming to provide solution to the industrial problem

1. Evaluation of Measurement System Properties- Accuracy, Precision, Repeatability and Reproducibility (Handson experimentation) (*CO1*)

2. Verification of the proof of Central Limit Theorem applied on Sampling process of industrial data (Handson experimentation) (*CO2*)

3. Hypothesis Testing on industrial data including single tailed and two tailed operations (Handson experimentation) (*CO2*)

4. Fitting a Linear Regression model for the given industrial data and residual analysis (Handson experimentation) (*CO3*)

5. Analysis of Variance (ANOVA Testing) for the determination of GSM and BF (Breaking Force) properties of the raw paper material with Hypothesis Testing – (Real Time Industrial Case study) (*CO1, CO2*)

6. Evaluation of Process Stability & Capability Analysis of Ring Crush Test Procedure in Paper Industry (Real Time Industrial Case study) (*CO2*)

7. Principal Component Analysis for Factors Screening for the estimation process of Vertical Compression Strength of Corrugated Paper Boxes (Real Time Industrial Case study) (CO3)

8. Manufacturing Process Stability Evaluation for quality metrics of Sprocket Rework Operation (Real Time Industrial Case Study) (CO2)

9. Design and Modelling of State Space Smoothening models for Forecast application of sales billing (Real Time Industrial Case study) (CO3, CO5)

10. Hypothesis evaluation for machine variability operations in Surfactant Performance modelling of a laboratory Chemical Analyzer (Real Time Case study) (CO1, CO2)

11. Maximization of Machine Operability (Throughput) of Chemical Analyzer using Optimization Techniques (Real Time Case study) (CO4)

12. Inventory Management Control Operation for Logistic Company (Real Time Case study) (CO5)

Textbooks:

1. Douglas C. Montgomery, "Introduction to Statistical Quality Control", 7th Edition. Wiley Publication
2. Amin Zollanvari, "Machine Learning with Python Theory & Implementation", 1st Edition, Springer Publication
3. Hamdy A. Taha, "Operation Research an Introduction", 8th Edition, Pearson, PHI
4. Han J, Pei J, Tong H, "Data Mining Concepts & Techniques", 4th Edition, Elsevier, New Delhi

Reference Books:

1. Peihua Qiu, "Introduction to Statistical Process Control", CRC Press
2. Sheldon M. Ross, "Introduction to Probability & Statistics for Engineers & Scientists", 5th Edition, Elsevier
3. D. Sarkar, Raghav Bali, Tushar Sharma, "Practical Machine Learning with Python- A Problem Solver Guide to Building Real World Intelligent Systems", Apress Publication
4. J. K. Sharma, "Operation Research: Theory & Applications", 6th Edition, Trinity Press

Assessment: In-Semester-Assessment (25 Marks)

5. ***All the students are required (mandatory) to be present in person during the laboratory conduction session. The laboratory session will only be conducted in offline (in presence mode) only as it involves actual measurement procedure with hands-on tasks.***
6. The ISA will consist of awarding marks for the complete, successful and in time submission of minimum 10 dually graded experiments shared commonly between all the students during the laboratory session.
7. ***Graded marks for 10 experiments will be converted to ISA marks of 25 (see the list of experiments above) Only one repeat session is allowed to cover up the missed lab session.***
8. Students will be awarded grade / or marks on each experiment based on his / her own contribution, showcasing the knowledge application skills, demonstrating measurement work, developing code / solution to the given problem and peer interaction. ***Student will lose the marks if he or she remains absent for the Laboratory Practical Session.***

Course Name: Industrial Internet of Things

Course Code: ET98T

Category: Professional Elective - 4 (Embedded IoT Track)

Preamble:

The pervasive integration of sensors, actuators, and communication technologies is rapidly transforming industries. This course, Industrial IoT, equips students with the knowledge and skills to design, develop, and implement Industrial Internet of Things (IIoT) solutions. It delves into advanced topics like industrial communication protocols, edge computing, security, and data analytics specific to industrial applications. Through lectures, assignments, and projects, students will gain a comprehensive understanding of the IIoT landscape and its potential to revolutionize industrial processes.

Pre-requisites:

- Smart Sensors & IoT
- Cloud Computing & IoT

Course Objectives:

- Equip students with a thorough understanding of the key concepts, technologies, and applications of Industrial IoT.
- Develop the ability to design and implement robust and secure IIoT solutions for various industrial scenarios.
- Foster critical thinking and problem-solving skills to address challenges in industrial automation using IIoT.
- Enhance knowledge on data analytics techniques for extracting valuable insights from industrial data.
- Prepare students for careers in industrial automation, process control, and related fields leveraging IIoT.

Course Outcomes:

Student will be able to:

CO1: Analyze the architecture and key components of Industrial IoT systems.
CO2: Select appropriate industrial communication protocols for specific applications.
CO3: Design and implement secure IIoT solutions considering data privacy and integrity.
CO4: Apply edge computing principles for real-time data processing in industrial settings.
CO5: Utilize data analytics tools to extract meaningful information from industrial data streams.
CO6: Evaluate and propose IIoT solutions for various industrial automation problems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head	ISA	MSA	ESE	Total (Passing @45% of total)
Theory	40	20	40	100
Lab	25	--	--	25

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 Industrial IoT	Definition, concepts, and applications of Industrial IoT (IIoT). Industrial automation and its evolution with IIoT. Key enabling technologies for IIoT (sensors, actuators, communication). .Industrial IoT reference architecture	4
2	Industrial Communication Protocols	Introduction to Industrial Ethernet protocols (PROFINET, EtherCAT). Fieldbus protocols for industrial automation (Modbus, HART). Wireless communication protocols for IIoT (Wi-Fi, Cellular, LPWAN). Selecting the right communication protocol for an IIoT application.	10
3	Security in Industrial IoT	Security challenges in IIoT systems (data integrity, privacy, access control). Secure communication protocols and encryption techniques. Authentication and authorization mechanisms for IIoT devices. Security best practices for deploying and managing IIoT solutions.	9
4	Edge Computing for Industrial IoT	Edge computing concepts and its role in IIoT. Benefits of edge computing for real-time processing and analytics. Edge computing platforms and technologies. Designing and implementing edge computing solutions for industrial applications.	10

5	Data Analytics for Industrial IoT	Industrial data collection, storage, and management. Data analytics techniques for IIoT (descriptive, predictive, prescriptive). Machine learning and artificial intelligence for industrial data analysis. Industrial case studies utilizing data analytics.	6
6	Industrial IoT Applications and Case Studies	IIoT applications in various industries (manufacturing, energy, logistics). Case studies of successful IIoT deployments. Project-based learning: Design and develop an IIoT solution for a specific industrial problem. Future trends and advancements in Industrial IoT.	6
Total			**45**

Textbooks:

5. Industrial Automation: Technologies and Systems by John R. Hackman
6. Industrial Internet of Things: Networking, Security, and Applications by Dominik Voigt, Michael E. Zwick, and Aditya Puthan
7. Designing the Industrial Internet of Things by Adrian McEwen and Hitesh Mehta
8. Hands-On Industrial Internet of Things by Giacomo Veneri, Antonio Capasso, and Daniel Souza

Reference Books:

5. Industrial Communication Systems: Interoperability, Performance, and Security by Ferenc Bacsó and József Csibi
6. Designing Secure Architectures for the Internet of Things by Peter Friess and Pietro Spognataro
7. Edge Computing for the Internet of Things by Michael Villalpando and Emad S. Al-Qasimi

Assessment:

7. **ISA (In-Semester-Assessment):** In semester assessment will carry total 40 marks. It will consist of 4 graded assignments based on modules – 1, 2, 3, and 4 (each carrying 10 marks). The assignments are self-study work and need to be completed by individual students separately. Every student will be submitting four completed assignments. ***These assignments should be different from each of the students. (No common problem solving).*** Students are encouraged to develop their own problem statements and devise a proper method / solution. Importance will be given to the concept understanding and applying it to solve the industrial problem using Python coding. ***Students are encouraged to take upon real industrial problem and not any dummy data model.***

8. **MSA (Mid-Semester-Assessment):** Mid Semester Assessment will consist of single mid semester internal theory test carrying 20 marks based on completion of minimum 2 chapters. This test will be common for all the students. ***Repeat examination will not be conducted.***

9. **ESE (End-Semester-Examination):** End Semester Examination will be conducted for total of 40 marks based on the completion of remaining modules post completion of mid semester examination or an entire syllabus. This test will be common for all the students.

Course Name: Industrial Internet of Things Lab

Course Code: ET98P

Category: Professional Elective - 4 (Embedded IoT Track)

Preamble:

The true power of IIoT lies in its practical implementation. This practical component is designed to bridge the gap between theory and practice by providing you with hands-on experience in designing, developing, and deploying IIoT solutions.

Pre-requisites:
Students should have the basic understanding of

- Computer Programming: Basic programming skills in languages like Python or C++ will be advantageous.
- Networking Fundamentals: Understanding network concepts like IP addressing, protocols (TCP/IP), and network topologies.
- Industrial Automation Concepts: A basic grasp of industrial automation principles, including sensors, actuators, controllers, and Programmable Logic Controllers (PLCs).
- Cloud Platforms: If practical involve cloud integration (e.g., AWS IoT, Azure IoT), some understanding of these platforms.
-

Course Objectives:

The practical component of the Advanced IIoT course aims to:

- Equip students with hands-on experience in designing, developing, and deploying IIoT solutions.
- Develop practical skills in using various tools and technologies relevant to IIoT, including hardware platforms, software tools, and communication protocols.
- Foster problem-solving skills by applying theoretical knowledge to real-world scenarios and troubleshooting technical challenges in IIoT systems.
- Enhance teamwork and collaboration through project-based learning activities that require students to work together effectively.

Course Outcomes:

Student will be able to:

CO1: Design and implement basic IIoT systems using sensors, actuators, and communication protocols

CO2: Utilize software tools for data acquisition, analysis, and visualization in an IIoT context.

CO3: Develop and deploy simple applications for data processing and anomaly detection on edge devices.

CO4: Configure and manage secure communication between IIoT devices and cloud platforms.

CO5: Effectively communicate technical concepts and project findings through reports and presentations.

Course Scheme:

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

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

Note – It is mandatory that, student must have prior sound knowledge of various sensors used in IoT and sensor data storage techniques. Also students are required to knowledge of data communication techniques and communication protocols:

- Industrial Scenario Identification- Identify an industry or process and brainstorm potential applications of IIoT in that specific scenario. Define the data to be collected, desired outcomes, and challenges to consider.
- Data Collection from IoT Sensors, Data Cleaning and Pre-processing for IoT Data
- Data Visualization on Cloud Platform: Connect sensors to a cloud platform (e.g., AWS IoT, Azure IoT) and develop a dashboard to visualize real-time or historical sensor data.
- Simulator-based Communication Protocol Exploration- Simulate communication between industrial devices using software or online tools. Experiment with different protocols (e.g., Modbus, PROFINET) and analyze data exchange.
- Security Assessment of an IIoT System- Analyze a hypothetical or real-world IIoT system for potential security vulnerabilities. Identify critical data points and suggest security measures to mitigate risks.
- Secure Communication with TLS/SSL: Set up secure communication between IIoT devices using Transport Layer Security (TLS) or Secure Sockets Layer (SSL) protocols.
- Edge Data Processing Simulation- Simulate an edge computing scenario where sensor data is processed locally before transmission. Use tools or platforms to implement simple data filtering, aggregation, or anomaly detection algorithms on edge devices.
- Industrial Data Analysis with Python Libraries- Explore libraries like Pandas and matplotlib for data analysis. Work with real or simulated industrial datasets to perform tasks like data cleaning, visualization, and basic statistical analysis.
- IIoT Solution Design Project: Select a specific industrial problem and propose an IIoT solution. Define the system architecture, communication protocols, data analytics approach, and potential challenges. You can present your solution using prototyping tools or simulation software.

Textbooks:

5. Industrial Automation: Technologies and Systems by John R. Hackman
6. Industrial Internet of Things: Networking, Security, and Applications by Dominik Voigt, Michael E. Zwick, and Aditya Puthan
7. Designing the Industrial Internet of Things by Adrian McEwen and Hitesh Mehta
8. Hands-On Industrial Internet of Things by Giacomo Veneri, Antonio Capasso, and Daniel Souza

Reference Books:

5. Industrial Communication Systems: Interoperability, Performance, and Security by Ferenc Bacsó and József Csibi
6. Designing Secure Architectures for the Internet of Things by Peter Friess and Pietro Spognataro
7. Edge Computing for the Internet of Things by Michael Villalpando and Emad S. Al-Qasimi

Assessment: In-Semester-Assessment (25 Marks)

9. All the students are required (mandatory) to be present in person during the laboratory conduction session. The laboratory session will only be conducted in offline (in presence mode) only as it involves actual measurement procedure with hands-on tasks.

10. The ISA will consist of awarding marks for the complete, successful and in time submission of minimum 10 dually graded experiments shared commonly between all the students during the laboratory session.

11. Graded marks for 10 experiments will be converted to ISA marks of 25 (see the list of experiments above) Only one repeat session is allowed to cover up the missed lab session.

12. Students will be awarded grade / or marks on each experiment based on his / her own contribution, showcasing the knowledge application skills, demonstrating measurement work, developing code / solution to the given problem and peer interaction. ***Student will lose the marks if he or she remains absent for the Laboratory Practical Session.***

Course Name: Integrated Circuits for Wireless Communication

Course Code: ET86

Category : Professional Elective – 4 (VLSI Track)

Preamble:

This course introduces students Importance of Radio frequency VLSI Design in the field of Eletronics and

telecommunication. Methodologies for analysis and designing of fundamental Radio

frequency signal circuits.

Pre-requisites:

Basic Electrical and Electronics Engineering. – Strongly Related

Electronics circuits and Devices. - Strongly Related.

Circuit Theory- Strongly Related

Microelectronics- Strongly Related

Digital VLSI Design with VERILOG- Strongly Related

Analog IC Design- Strongly Related

Course Outcome:

Student will be able to :

1) Understand Architecture of RF Communication
Transceiver.
2)Analyze and design Low Noise Amplifier.
3)Understand Analysis and designing of RF Mixers and Oscillator circuits.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Basic Concept in RF Design :	General Consideration units in RF design. Time variance.Nonlinearity.Effects of Non linearity Sensitivity Dynamic Range.Impedance Transformation.	09
2	Architecture: Transceiver	Receiver Architecture, Modern heterodyne direct conversion, Image Rejection and low IF Receivers. Transmitter Architecture direct conversion transmission modern direct conversion transmitter heterodyne transmitter.	09
3	Low Noise Amplifier :	General Consideration, Problem of input impedance matching, various LNA topologies. High IP2 LNA	09
4	Mixer's:	General consideration, performance Parameters, Mixer noise figure. Signal balanced and Double balanced mixers passive and active down conversion mixers.	09
5	Oscillators:	Performance parameter Basic Principles, cross coupled oscillator VCO, VCO with wide turning Range.	09
Total			**45**

Text Books:

1. RF Microelectronics by B. Razavi 2nd Edition,Prentice Hall
2. Low PowRF Circuit Design in standard CMOS Technology By Aluarado U Springer Oct 2011 Edition.

Reference Books:

1. VLSI for Wireless communication by Bosco Leung Springer 2nd Edition.

Machine Learning

Couse Code – ET99

Category : Professional Elective – 4 (ML Track)

Course Objectives:

The course aims to provide the student with:

1. An understanding of the basic concepts of classification, clustering, predication and regression

2. Knowledge of the advanced methods of classification and clustering

3. An ability to compute the classification accuracy

4. An understanding of the concept of dimensionality reduction

Course Outcomes:

After completion of the course the student will be able to :

CO1 Explain the basic and advanced concepts of classification and clustering

CO2 Design and implement machine learning solutions to classification, regression, and clustering problems.

CO3 Evaluate and interpret the results of the algorithms

CO4 Compute the classification accuracy

Unit1	Hours
Basic Concepts (Theory and Numerical): What is Machine Learning? Supervised and Unsupervised Learning, Classification and Prediction, Issues Regarding Classification and Prediction, Decision Tree, Bayesian Classification, Rule-Based Classification, Random Forest	10
Unit2	
Classification by Backpropagation, Support Vector Machines, K nearest neighbors, Associative classification, lazy learners, Accuracy and Error Measures (Confusion matrix, Precision and Recall)	10
Unit3	
Other classification Methods: Genetic Algorithms, Rough set and Fuzzy set Approach Prediction: Linear (Simple & Multiple), Simple linear regression, or Predictor, Ensemble Methods—Increasing the Accuracy	10
Unit3	
Cluster Analysis: Basic Concepts and Methods (Theory and Numerical): Cluster Analysis, Partitioning Methods, Hierarchical Methods, Density-Based Methods, Grid-Based Methods, Evaluation of Clustering models, outlier analysis	10
Unit4	
Dimensionality Reduction, Reinforcement learning	5

Textbook	
1	J. Han and M. Kamber, “Data Mining: Concepts and Techniques”, Third Edition, Elsevier
References	
1	M. H. Dunham. Data Mining: Introductory and Advanced Topics, 1e, Pearson Education. 2010
2	Cios, K.J., Pedrycz, W., Swiniarski, R.W., Kurgan, L. “Data Mining A Knowledge Discovery Approach”, Springer, 2007
3	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “Introduction to Statistical Learning”, Springer, 2013
4	Richard Duda, Peter Hart, David Stork, “Pattern Classification”, John Wiley & Sons,2nd Ed., 2001.

Course Name: IPR and Patenting

Course Code: OE06

Category: Open Elective

Preamble: This course aims to help learners understand IPR and its management. It will introduce the learners to different types of IPR and patenting processes for innovation and commercialization of the IPR. The learners will also learn about the various strategies to manage and protect the IPR.

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 acquainted with Patent search and patent filing procedures and applications.
- To familiarize with the IPR Management and Commercialization Process.

Course Outcome:

- Understand Intellectual Property assets
- Assist individuals and organizations in capacity-building
- Work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting
- Apply the IPR understanding in policy design, NDA Forms, Contributing to Standards and other processes.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Capstone Project	Theory	Cap-stone Project
3	2	3	1

Contact Hours	**Credits Assigned**
Theory	Theory +Capstone Project
	4

Assessment Guidelines:

ISA	MSE	ESE	Capstone Project	Total
20	30	50	50	150

Capstone Project:

50 Marks = where students must Apply for their Copyright/Design Patent/Patent Application.

This session will be conducted in workshop/Online/Home Assignment mode.

Detailed Syllabus

Module	Detailed Content	Hours
1	**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	5
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.	10
3	**Emerging Issues in IPR** • Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	5
4	**Basics of Patents** • Definition of Patents, Conditions of patentability, Patentable and non-patentable 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	10
5	**Patent Rules** • Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treatieswhere India is a member (TRIPS agreement, Paris convention	10

	etc.) **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	
6	**IPR Management** • IPR management Strategies, IPR Commercialization Strategies • IPR Dispute and Negotiation strategies • Participation in Standards and Public Funding • IPR Policymaking and developing innovation eco-system	5
Total		**45**

Guidelines to conduct practical/home assignment sessions:

7. An individual or a group of two students will conduct the capstone project.
8. To encourage project-based learning in the curriculum, students may select one of the subjects of their choice after the subject in charge reviews and approves it.
9. Each individual l/team will conduct a rigorous literature survey of the IPR Subject by reading and understanding at least 3-5 Patent/IPR papers from current, high-quality national/international Patents/IPR search engines. The list of documents surveyed must be documented.
10. The project assessment for term work will be done at least twice a semester, and it will involve giving a presentation to the faculty in charge or a panel of expert members.

Deliverables of the capstone project by the student or the group:

Sr. No	Deliverables	Hours in Practical Session	Hours as a home assignment
1	A report summarizing the findings of the literature survey.	3	3
2	Prior Artwork	3	3
3	Preparing own IPR and Other Reading Material	3	3
4	Final Draft with application	3	3
5	Detailed synopsis of the submitted application	3	3
Total		**15**	**15**

Skill Set (H, M, L)

4. Building your IPR Understanding (H)

5. Learning different tools (H)
6. Analysis of the Prior Art Work (M)

Tool Set

4. Search Engines
5. Assessment/Feedback/Survey

Module Mapping

Module	Skill Set	Tool Set
Module 1	1	-
Module 2	1	-
Module 3	1	-
Module 4	1,2,3	1,2
Module 5	1,2,3	1,2
Module 6	2,3	1,2

Recommended Online Courses:

1. https://l2proindia.com/index.php#item1 (GOI and Qualcomm Course)
2. https://onlinecourses.swayam2.ac.in/aic24_ge17/preview (Swayam)
3. https://welc.wipo.int/ipedu/ (WIPO Portals)
4. https://www.youtube.com/@turnipinno/videos (Turnip)

Textbooks and References:

1. Rajkumar S. Adukia, 2007, *A Handbook on Laws Relating to Intellectual PropertyRights 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 HumanDevelopment: 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*, 3rdEdition, WIPO
7. Prabhuddha Ganguli, 2012, *Intellectual Property Rights*, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, *Intellectual Property Rights*, 1stEdition, 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*, 1stEdition, 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, Interpretationof 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: Sustainability Management

Course Code: OE04

Category: Open Elective

Preamble:
This course explores corporate sustainability from the perspective of large, multinational corporations. Focus is on the management tools available to corporations and how they can drive sustainability into a company at all levels, providing a balance between environmental stewardship, social well-being, and economic prosperity.

Objectives:
1. The importance to each individual corporate entity of corporate sustainability.
2. Key drivers and inhibitors, both external and internal to the corporation, of the natural environmental and social aspects of corporate sustainability.
3. The roles of social and natural environmental risk, and product and process innovation, in developing corporate sustainability.

Course Outcome: Student will be able to:
1. Define sustainability and identify major sustainability challenges.
2. Identify, act on, and evaluate their professional and personal actions with the knowledge and appreciation of interconnections among economic, environmental, and social perspectives.
3. Recognize the global implications of their actions.
4. Apply concepts of sustainable development to address sustainability challenges in a global context.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module no	Module Name	Content	No of Hours
1	Introduction to Sustainability Management	Meaning, definition, dimensions of sustainability, value of sustainability, framework for business sustainability Understanding the Sustainability Challenge- The Systemic Level and Business Level, Their Implications for business.	12

Module no	Module Name	Content	No of Hours
2	Importance of Corporate Sustainability	Assessing the Strategic Opportunity, Managing Sustainability Transitions across Business Functions, successful cases of organizations focusing on a business model designed around sustainability principles and mind-sets.	12
3	Seizing the Strategic Opportunity	Managing Sustainability Transitions across Business Functions, the challenges related to the management of the integration of sustainability-related processes in business organizations.	12
4	Stakeholder Engagement	Multilateral engagement, Government engagement, NGO's – influence and engagement, Trade associations (WBCSD), Stakeholder interests and engagement	12
5	Transitioning Organizations to Sustainable Enterprises	Developing the Road-Map, Approach the challenge of developing a roadmap to realize the stakeholder value creation potential in sustainability transitions at three different levels, initiatives related to transformational change in the organizations.	12
Total			**60**

Textbooks:

1. Corporate Sustainability in Practice: A Guide for Strategy Development and Implementation by Paolo Taticchi, Melissa Demartini
2. Corporate Sustainability, Social Responsibility and Environmental Management: An Introduction to Theory and Practice with Case Studies by Mark Anthony Camilleri.

Reference-Books:

1. How to Succeed as an Independent Consultant by Holtz, Herman.
2. Strategy for Sustainability: A Business Manifest by Adam Werbach.

E- Resources:

1. Global Journal of Management and Business Research: D Accounting and Auditing
2. Indian Journal of Finance - http://www.indianjournaloffinance.co.in/
3. IVEY Business Journal- https://iveybusinessjournal.com/publication/corporate-sustainability-what-is-it-and-where-does-it-come-from/

MOOC:

1. https://www.coursera.org/learn/corp-
2. https://www.edx.org/course/introduction-to-corporate-sustainability-social-in
3. https://www.classcentral.com/course/corp-sustainability-10667

Course Name: Operation Research

Course Code: OE05

Category: Open Elective

Pre-requisites:

- Mathematics

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 Outcome:

- Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- 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. Understand the applications of integer programming and a queuing model and compute important performance measures.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module	Detailed Content	Hours
1	**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, SimplexMethod	13

	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 stepping stone method and MODI method. **Assignment Problem** • Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m 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.	05
2	**Queuing models** • Queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	09
3	**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	10
4	**Dynamic programming** • Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	08
5	**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.	10
6	**Inventory Models** • Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05
	Total	**60**

Textbooks and References:

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.

Appendix-A

Guidelines for Professional Elective Courses and Specialization Certificate

Professional Elective courses are designed to meet industrial requirements. All learners must opt for 4 professional elective courses as a part of requirement for M.Tech. degree.

Specialization Certificate is introduced in order to build competency of learners in the chosen domain. Department of Computer Engineering offers the following specialization tracks:

1. Embedded & IoT
2. VLSI
3. Machine Learning

Learners can take courses from any track. **However, if learners complete all Professional Elective Courses from the same chosen track, they will be eligible to receive a Specialization Certificate from the Institute.**

Learners who choose professional elective courses from different specialisation tracks will not be eligible for a Specialization Certificate.

It should be noted that there are no additional credit requirements for these specialisations.

Embedded & IoT: Courses to be chosen for specialization in Embedded & IoT

Preferred Semester	Course Code	Course Name
I	ET79	Embedded Communication Systems Design
I	ET93	Cloud Computing & IoT
II	ET81	Smart Sensors & IoT
II	ET98	Industrial IoT

VLSI track: Courses to be chosen for specialization in VLSI

Preferred Semester	Course Code	Course Name
I	ET83	Sensor Technology MEMS & NEMS
I	ET84	Analog & Mixed Signal Circuit Design
II	ET85	VLSI & Signal Processing
II	ET86	Integrated Circuits for Wireless Communication

Machine Learning track: Courses to be chosen for specialization in ML

Preferred Semester	Course Code	Course Name
I	ET92	Fundamentals of Machine Learning
I	ET94	Data Warehousing & Mining
II	ET97	Industrial Data Analytics & Optimization
II	ET99	Machine Learning

Appendix B

Courses under Open Elective (OE) Category

Sr. No.	Course Code	Course Name	Hours Per Week		Credits	Preferred Semester
			Theory	Practical		
1	OE04	Sustainability Management	4	-	4	2
2	OE05	Operation Research	4	-	4	2
3	OE06	IPR and Patenting	4	-	4	2
4	OE07	Research Methodology	4	-	4	1
5		Teaching Pedagogy & Education Technology	4	--	4	1
6	OE13*	Online Course 1 (MOOC)	As per course		2	-
7	OE14*	Online Course 2 (MOOC)	As per course		2	-

*Online Courses (MOOC) of 2 credits is equivalent to 30 hours course.