KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY
(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)
S.P.G.Chidambara Nadar - C.Nagammal Campus
S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

Elective Courses included for doing Phd Course Work

S.NO.	COURSE CODE	COURSE NAME	L	T	P	C
1.	MC1137	Design of Experiments	3	0	0	3
2.	MC1138	Big Data	3	0	0	3
3.	MC1139	Deep Learning	3	0	0	3
4.	MC1140	Machine Learning	3	0	0	3
5.	CN1137	Internet of Things	3	0	0	3
6.	MA1131	Advanced Linear Algebra	3	0	0	3
7.	MA1132	Numerical Methods and Computing	3	0	0	3
8.	MA1133	Probability and Statistical Analysis	3	0	0	3

S.NO.	COURSE CODE	COURSE NAME	L	T	P	C
1.	PS1137	Advanced Power Converters	3	0	0	3
2.	PS1138	Digital Controllers for Power Electronics	3	0	0	3
3.	PS1139	Principles of Electrical Safety and Management	3	0	0	3
4.	PS1140	Research Methodology	3	0	0	3
5.	PS1141	Sustainable Energy Conversion Systems	3	0	0	3
6.	MF1135	Composite Technology	3	0	0	3
7.	MF1136	Fundamentals of Additive Manufacturing Techniques	3	0	0	3
8.	MF1137	Material Testing and Characterization Techniques	3	0	0	3

Course Code	Course Name	L	T	P	C
MC1137	DESIGN OF EXPERIMENTS	3	0	0	3

OBJECTIVES

- Impart knowledge on principles and steps in designing a statistically designed experiment.
- Build foundation in analyzing the data in single factor experiments and to perform post hoc tests.
- Provide knowledge on analyzing the data in factorial experiments.
- Educate on analyzing the data analysis in special experimental designs and Response Surface Methods.
- Impart knowledge in designing and analyzing the data in Taguchi's Design of Experiments to improve Process / Product quality.

EXPERIMENTAL DESIGN FUNDAMENTALS **9**

Importance of experiments, experimental strategies, basic principles of design, terminology, ANOVA, steps in experimentation, sample size, normal probability plot, and linear regression models.

SINGLE FACTOR EXPERIMENTS **9**

Completely randomized design, Randomized block design, Latin square design. Statistical analysis, estimation of model parameters, model adequacy checking, pair wise comparison tests.

MULTIFACTOR EXPERIMENTS **9**

Two and three factor full factorial experiments, Randomized block factorial design, Experiments with random factors, rules for expected mean squares, approximate F- tests. 2K factorial Experiments.

SPECIAL EXPERIMENTAL DESIGNS **9**

Blocking and confounding in 2^K designs. Two level Fractional factorial design, nested designs, Split plot design, Introduction to Response Surface Methods.

FAULT TRACING **9**

Steps in experimentation, design using Orthogonal Arrays, data analysis, Robust design-control and noise factors, S/N ratios, parameter design, Multi-level experiments, Multi-response optimization, Introduction to Shainin DOE.

TOTAL: 45 PERIODS

OUTCOMES

CO1: Describe the fundamental principles of Design of Experiments

CO2: Analyze data in the single factor experiments.

CO3: Analyze data in the multifactor experiments.

CO4: Explain the special experimental designs & Response Surface Methods.

CO5: Apply Taguchi based approach to evaluate quality.

REFERENCE BOOKS

1. Krishnaiah, K. and Shahabudeen, P. Applied Design of Experiments and Taguchi Methods, PHI learning private Ltd., 2012.
2. Montgomery, D.C., Design and Analysis of experiments, John Wiley and Sons, Eighth edition, 2012.
3. NicoloBelavendram, Quality by Design; Taguchi techniques for industrial experimentation, Prentice Hall, 1995.
4. Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 1996.
5. Montgomery, D.C., Design and Analysis of Experiment, Minitab Manual, John Wiley and Sons, Seventh edition, 2010.

Course Code	Course Name	L	T	P	C
MC1138	BIG DATA	3	0	0	3

Category:

a. Preamble

This course emphasizes the practical real-world applications of big data using Spark, empowering to construct scalable applications utilizing machine learning models.

b. Course Outcome (Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the characteristics of Big Data and its architecture	K2
CO2	Utilize the Python API for Apache Spark to perform data processing	K3
CO3	Implement query operations using PySpark SQL	K3
CO4	Interpret the real time stream processing using Kafka	K3
CO5	Apply machine learning techniques using MLlib.	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION **9**

Introduction - Understanding Big Data - Capturing Big Data - Big Data Benefit - Big Data Management - Organizing Big Data - Analyzing Big Data - Big Data Challenges - Standard Big Data Architecture - Introduction to Apache Hadoop - Introduction to Apache Spark.

PYSPARK **9**

Introduction - Features - Advantages - PySpark Architecture - Cluster Manager Types - Modules and Packages - Installation on Windows - RDD Creations and Operations - DataFrame: DataFrame Creation, Convert PySpark RDD to DataFrame and Pandas, Functions, DataSource.

PYSPARK SQL **9**

Introduction - Basic Transformations - Managing Tables - Basic DDL and DML in Spark SQL - DML and Create Partitioned Tables - Spark SQL Functions to Manipulate strings, dates, null values - Windowing Functions Ranking.

STREAM PROCESSING USING KAFKA **9**

Introduction - Kafka Components - Cluster Architecture - Workflow - Role of ZooKeeper - Kafka Installation - Basics Operations: Single Node-Single Broker Configuration, Single node-Multiple Brokers Configuration - Creating a Topic - Basic Topic Operations: Modifying and Deleting - Apache Kafka - Simple Producer Example - Producer API - Producer Record API - Simple Consumer Example - Consumer Record API - Consumer Records API.

MACHINE LEARNING USING MLLIB **9**

Introduction - Spark MLlib - Building ML Pipelines with PySpark - Hyper-parameter Tuning - Implementing Linear Regression: Performing Exploratory Data Analysis, Dealing with Categorical Data, Feature Engineering, Build and Train Linear Regression model, Prediction from the model - Classification using PySpark: Logistic Regression, Decision Tree, Random Forest.

d. Learning Resources

Text Books

1. Anil Maheshwari, *"Big Data"*, 1st edition, McGraw Hill Education, 2017.

Web References

1. https://sparkbyexamples.com/pyspark-tutorial/
2. https://www.tutorialspoint.com/apache_kafka/apache_kafka_quick_guide.htm
3. https://sparkbyexamples.com/pyspark/pyspark-sql-with-examples/

Reference Books

1. Seema Acharya, Subhashini Chellappan, *"Big Data and Analytics"*, 2nd Edition, Wiley, 2019.
2. DT Editorial Services, *"Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization"*, 1st Edition, Dreamtech Press, 2016.
3. Ankam. V, *"Big Data Analytics"*, 1st Edition, Packt Publishing Ltd., 2016.
4. https://www.projectpro.io/hadoop-tutorial/pyspark-machine-learning-tutorial.

Course Code	Course Name	L	T	P	C
MC1139	DEEP LEARNING	3	0	0	3

Category:

a. Preamble

This course enables the student to understand the basic concepts of machine learning. This helps the students to dive into deep feed-forward network. This courses makes the student to get explore to various deep learning algorithms like Convolution Neural Network and Recurrent Neural Network. This course familiarizes the students about the use of deep learning frameworks in real life problems.

b. Course Outcome (Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the supervised and unsupervised learning to solve real time problems.	K3
CO2	Develop, train and optimize a deep model with appropriate activation functions.	K3
CO3	Model and train the convolution neural network with appropriate hyper parameters.	K3
CO4	Utilize Recurrent Neural Network in various domains	K3
CO5	Implement deep learning algorithms with the suitable framework for solving real world problems.	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION **9**

Introduction to Machine Learning - Learning Algorithm - Overfitting and Underfitting - Hyperparameters - Estimators, Bias and Variance - Maximum Likelihood Estimation - Bayesian Statistics - Supervised Learning Algorithm - Unsupervised Learning Algorithm - Stochastic Gradient Descent - Building a Machine Learning Algorithm - Challenges Motivating Deep Learning.

DEEP NETWORKS **9**

Deep Feedforward Networks : Learning XOR, Gradient - Based Learning, Hidden Units, Architecture Design, Back - Propagation and Other Differentiation Algorithms -

Regularization : Parameter Norm Penalties, Dataset augmentation, Early Stopping, Parameter Typing and Parameter Sharing, Sparse representation - Optimization for training Deep models: Learning Vs Optimization - Basic Algorithms.

CONVOLUTIONAL NETWORKS **9**

Convolution Operation - Motivation - Pooling - Convolution and Pooling as an Infinte Strong Prior - Efficient Convolution Algorithms - Random or Unsupervised Features - The Neuroscientific Basis for Convolutional Networks - Convolutional Networks and the History of Deep Learning.

RECURRENT NEURAL NETWORKS **9**

Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs – Encoder - Decoder Sequence - to - Sequence Architectures - Deep Recurrent Networks - Recursive Neural Networks - Challenges of Long-Term Dependencies - Echo State Networks - Leaky Units and Other Strategies for Multiple Time Scales - LSTM and other Grated RNNs - Optimization for Long-Term Dependencies - Explicit Memory.

APPLICATIONS AND TOOLS **9**

Applications: Large Scale Deep Learning, Computer Vision, Speech Recognition, Natural Language Processing - Tools : TensorFlow, PyTorch, Keras, ImageAI.

d. Learning Resources

Text Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *"Deep Learning"*, The MIT Press, 2017.

Reference Books

1. Josh Patterson and Adam Gibson, *"Deep Learning A Practitioner's Approach",* O'Reilly Media Inc., 2017.
2. Li Deng, Dong Yu, *"Deep Learning: Methods and Applications*", Now Publishers, 2014.
2. Jojo Moolayil, *"Learn Keras for Deep Neural Networks*", Apress, 2018.
3. Vinita Silaparasetty, *"Deep Learning Projects Using TensorFlow 2*", Apress, 2020.

Course Code	Course Name	L	T	P	C
MC1140	MACHINE LEARNING	3	0	0	3

Category:

a. Preamble

This course enables the students to understand the basics of Machine Learning techniques. This course focuses on the study of machine learning fundamentals with python programming language for supervised and unsupervised learning algorithms.

b. Course Outcome (Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamental concepts of machine learning.	K2
CO2	Solve real time problems using various types of linear models.	K3
CO3	Apply various types of tree based and probabilistic model algorithms.	K3
CO4	Utilize various dimensionality reduction methods and evolutionary models	K3
CO5	Construct various graphical models for a real time problem.	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION **9**

Learning - Types of Machine Learning - Supervised Learning - Machine Learning Process - Curse of Dimensionality, Overfitting - Performance Measures: Confusion Matrix - Accuracy Metrics - Bias - Variance Tradeoff - Perceptron - Linear Separability - Linear Regression.

LINEAR MODELS **9**

Multi-layer Perceptron - Going Forwards - Going Backwards: Back Propagation Error - Multi - layer Perceptron in Practice - Examples of using the MLP - Overview - Deriving Back - Propagation - Radial Basis Functions and Splines - Concepts - RBF Network - Curse of Dimensionality - Interpolations and Basis Functions - Support Vector Machines.

TREE AND PROBABILISTIC MODELS **9**

Learning with Trees - Decision Trees - Constructing Decision Trees - Classification and Regression Trees - Ensemble Learning - Boosting - Bagging - Different ways to Combine Classifiers - Probability and Learning - Data into Probabilities - Basic Statistics - Gaussian Mixture Models - Nearest Neighbor Methods - Unsupervised Learning - K means Algorithms - Vector Quantization - Self Organizing Feature Map.

DIMENSIONALITY REDUCTION AND EVOLUTIONARY M(**9**

Dimensionality Reduction - Linear Discriminant Analysis - Principal Component Analysis - Factor Analysis - Independent Component Analysis - Locally Linear Embedding - Isomap - Least Squares Optimization - Evolutionary Learning - Genetic algorithms - Genetic Offspring: - Genetic Operators - Using Genetic Algorithms - Reinforcement Learning - Overview - Getting Lost Example - Markov Decision Process.

GRAPHICAL MODELS **9**

Markov Chain Monte Carlo Methods - Sampling - Proposal Distribution - Markov Chain Monte Carlo - Graphical Models - Bayesian Networks - Markov Random Fields - Hidden Markov Models - Tracking Methods.

d. Activities

Students shall be exposed to python packages to solve simple problems.

e. Learning Resources

Text Books

1. Ethem Alpaydin, *Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)*, 3rd Edition, MIT Press, 2014.

Reference Books

1. Jason Bell, *Machine learning - Hands on for Developers and Technical Professionals*, 1st Edition, Wiley, 2014.
2. Peter Flach, *Machine Learning: The Art and Science of Algorithms that Make Sense of Data*, 1st Edition, Cambridge University Press, 2012.
3. Stephen Marsland, *Machine Learning - An Algorithmic Perspective*, 2nd Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
4. Tom M Mitchell, *Machine Learning*, 1st Edition, McGraw Hill Education, 2013.

Course Code	Course Name	L	T	P	C
CN1137	INTERNET OF THINGS	3	1	0	4

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To build a small low cost embedded system using Raspberry Pi.
- To apply the concept of Internet of Things in the real world scenario.

INTRODUCTION TO IOT **9**

Internet of Things - Physical Design - Logical Design - IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF - YANG - IoT Platforms Design Methodology.

IOT ARCHITECTURE **9**

M2M high - level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture .

IOT PROTOCOLS **9**

Protocol Standardization for IoT - Efforts - M2M and WSN Protocols - SCADA and RFID Protocols - Unified Data Standards - Protocols - IEEE 802.15.4 - BACNet Protocol - Modbus - Zigbee Architecture - Network layer - 6LowPAN - CoAP - Security.

BUILDING IOT WITH RASPBERRY PI & ARDUINO **9**

Building IOT with RASPERRY PI - IoT Systems - Logical Design using Python - IoT Physical Devices & Endpoints - IoT Device - Building blocks - Raspberry Pi –Board - Linux on Raspberry Pi-Raspberry Pi Interfaces - Programming Raspberry Pi with Python-Other IoT Platforms - Arduino.

CASE STUDIES AND REAL-WORLD APPLICATIONS **9**

Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT - Software &Management Tools for IoT Cloud Storage Models & Communication APIs- Cloud for IoT - Amazon Web Services for IoT.

TOTAL : 45 PERIODS

Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Analyze various protocols for IoT

CO2: Develop web services to access/control IoT devices.

CO3: Design a portable IoT using Rasperry Pi

CO4: Deploy an IoT application and connect to the cloud.

CO5: Analyze applications of IoT in real time scenario

REFERENCES:

1. Arshdeep Bahga & Vijay Madisetti, 2015, *Internet of Things - A hands - on approach*, Universities Press.
2. Dieter Uckelmann, Mark Harrison, Michahelles & Florian (Eds), 2011, *Architecting the Internet of Things*, Springer.
3. Honbo Zhou, 2012, *The Internet of Things in the Cloud : A Middleware Perspective*, CRC Press.
4. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand & David Boyle, 2014, *From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence*, Elsevier.
5. Olivier Hersent, David Boswarthick & Omar Elloumi, 2012, *The Internet of Things – Key applications and Protocols*, Wiley.

Course Code	Course Name	L	T	P	C
MA1131	ADVANCED LINEAR ALGEBRA	3	1	0	4

Category: Basic Science Courses

a. Preamble

The course aims to study the relation between a linear transformation and its matrix. Also It explores various characteristics of matrices using linear transformations.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the fundamentals of vector spaces, and linear transformations.	K3
CO2	Demonstrate linear functionals from a vector space.	K3
CO3	Construct characteristic roots and characteristic vectors of linear transformations.	K3
CO4	Apply the concepts of Matrix norms and relations in Matrices.	K3
CO5	Apply matrix analysis concept to solve problems.	K3

c. Course Syllabus **TOTAL : 60 PERIODS**

VECTOR SPACES **12**

Vector spaces - Subspaces - Sums and direct sums - Finite dimensional vector spaces - bases and dimensions - Linear maps - Null spaces and Range Spaces.

LINEAR FUNCTIONALS **12**

Linear Functionals - Examples - Dual space - Reflexivity - Transpose of a linear map - Examples - Theorems.

ORTHOGONALITY OF LINEAR TRANSFORMATION **12**

Eigen values and Eigenvectors - Orthogonality of Vectors - Schur's theorem (real and complex versions) - Spectral theorems for Normal and Hermitian Matrices (real and complex versions).

MATRIX NORM **12**

Matrix norms - Spectral radius formula - Relationships between matrix norms - Singular value decomposition - Polar decomposition - QR factorization.

PERTURBATION OF EIGEN VALUES **12**

General perturbation theory for matrices - Bauer-Fike and Henrici theorems - Hoffman - Wielandt theorem.

d. Activities

Students shall be solve the problems in Linear Map and Matrices.

e. Learning Resources

Text Books

1. R. A. Horn and C. R. Johnson, Matrix Analysis, CUP, 1985.

References

1. G.W. Stewart and J. G. Sun, Matrix Perturbation Theory, Academic Press, 1990.
2. Goyal J. K, Gupta K. P, Gupta G. S, Gupta S. S, Advanced Course in Modern Algebra", Pragati Prakashan Educational Publisher, Recent Edition 2021.

Course Code	Course Name	L	T	P	C
MA1132	NUMERICAL METHODS AND COMPUTING	3	1	0	4

Category: Basic Science Courses

a. Preamble

This course aims at developing the ability to solve engineering problem by choosing an appropriate numerical approach to obtain solution such as Eigen value problems, fitting a polynomial, ordinary differential equations and boundary value problems.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Solve nonlinear equations, system of linear equations and eigenvalue problems numerically.	K3
CO2	Construct approximate polynomial to represent the data and find the intermediate values of unknown function using interpolation.	K3
CO3	Apply the concepts of numerical methods for ordinary differential equations.	K3
CO4	Apply finite difference method for time dependent partial differential equation.	K3
CO5	Solve the boundary value problems numerically.	K3

c. Course Syllabus **TOTAL : 60 PERIODS**

ALGEBRAIC EQUATIONS AND EIGENVALUE PROBLEM **12**

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tri-diagonal system - Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev - Leverrier Method.

INTERPOLATION AND APPROXIMATION **12**

Central difference: Stirling and Bessel's interpolation formulae; Piecewise spline interpolation: Piecewise linear, piecewise quadratic and cubic spline.

ORDINARY DIFFERENTIAL EQUATIONS **12**

Runge Kutta Methods for system of IVPs, numerical stability, Adams - Bashforth multistep method, solution of stiff ODEs, shooting method, BVP : Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION **12**

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions - Two dimensional parabolic equations - ADI method; First order hyperbolic equations - method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines - Wave equation: Explicit scheme- Stability of above schemes.

FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS **12**

Laplace and Poisson's equations in a rectangular region : Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions - Laplace equation in polar coordinates: finite difference schemes - approximation of derivatives near a curved boundary while using a square mesh.

d. Activities

Students shall be exposed to MATLAB software to solve simple problems.

e. Learning Resources

Text Books

1. Burden, R L and Faires, J D, *Numerical Analysis, 9th Edition*, Cengage Learning, 2016.
2. Grewal, B S., and Grewal, J S, *Numerical Methods in Engineering and Science, Khanna Publishers, 10th Edition*, New Delhi, 2015.
3 Jain, M.K., Iyengar, S.R.K. and Jain, R.K., "*Computational Methods for Partial Differential Equations*", New Age Publishers, 1994.

References

1. S.R.K. Iyengar, R.K.Jain*,"Numerical Methods", New Age International Publishers, 1st edition*, India 2014.
2. Saumyen Guha and Rajesh Sriva stava, "*Numerical methods for Engineering and Science*", Oxford Higher Education, New Delhi, 2010.

3 Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, Asia, New Delhi. 2007.

4 Sastry, S S, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd, 5th Edition, New Delhi, 2015.

5 Gupta, S.K., *"Numerical Methods for Engineers", (Third Edition)*, New Age Publishers, 2015.

Course Code	Course Name	L	T	P	C
MA1133	PROBABILITY AND STATISTICAL ANALYSIS	3	1	0	4

Category: Basic mathematical skills in Probability and statistics, Data Science, Discrete Mathematics

a. Preamble

Study of this course provides the learners a clear understanding of fundamental concepts in probability and how to analyze various statistical problems. This course covers the modern theory of probability and statistics, important models of sampling, techniques of hypothesis testing and correlation & regression. The course helps the learners to find varied applications in engineering and science like disease modelling, climate prediction and computer networks.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the basic concepts of probability to solve engineering problems.	K3
CO2	Identify probability distributions to solve statistical problems.	K3
CO3	Make use of Estimation theory to calculate the parameters	K3
CO4	Construct statistical hypothesis and derive inference about samples.	K3
CO5	Develop critical thinking based on empirical evidence and the scientific approach to knowledge development.	K3

c. Course Syllabus **TOTAL : 60 PERIODS**

PROBABILITY &RANDOM VARIABLES **12**

Axiomatic approach to probability - Random variables - Discrete and continuous - Moments - Moment generating function - Discrete distribution: Binomial, Poisson and Geometric distribution - Continuous distribution: Exponential, Gamma,Weibull and Normal distribution. Case study in statistical inference (Fitting a binomial, Poisson and normal model for the sample of data using EXCEL / R Software / SPSS).

TWO DIMENSIONAL RANDOM VARIABLES **12**

Joint distributions - Marginal and Conditional distributions - Transformations of random variables - Correlation.- Regression.

ESTIMATION THEORY **12**

Unbiased estimators - Efficiency - Consistency - Sufficiency - Method of moments - Maximum Likelihood Estimation - Curve fitting by Principle of least squares.

TESTING OF HYPOTHESIS **12**

Sampling distributions - Tests of significance - Errors in sampling - One sample and two sample tests for mean and proportion of large samples (z-test) - One sample and two sample tests for means of small samples (t-test) - F-test - Chi square test for goodness of fit and independence of attributes.

MULTIVARIATE ANALYSIS **12**

Random Vectors and Matrices - Mean vectors and Covariance matrices - Multivariate Normal density and its properties - Principal components Population principal components - Principal components from standardized variables.

d. Activities

Students shall be exposed to EXCEL / R Software / SPSS to find statistical inferences.

e. Learning Resources

Text Book

1. Richard A. Johnson, “Miller and Freund’s Probability and Statistics for Engineers”. Pearson Education, 9th Edition, 2016.

References

1. Vijay K. Rohatgi and EhsanesSaleh A.K.MD., “An Introduction to Probability and Statistics”, John Wiley & Sons, 3rd Edition, 2015.
2. Milton S.J. and Arnold J.C., "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences", Mc Graw Hill - Education, 4th Edition, 2002.
3. Arora P. N. Smeet Arora and Arora S., “Comprehensive Statistical Methods”, Sultan Chand & Sons, 2nd Edition, 2007
4. Gupta S.C. and Kapoor V.K., “Fundamentals of Mathematical Statistics”, Sultan Chand & Sons, 12th Edition Reprint, 2020. 2.

5. Richard A. Johnson and Dean W.Wichern, “Applied Multivariate Statistical Analysis”, Pearson Education, Asia, Fifth Edition, 2002.
6. Dallas E Johnson, “Applied Multivariate Methods for Data Analysis”, Thomson and Duxbury Press,1998.

Course Code	Course Name	L	T	P	C
PS1137	ADVANCED POWER CONVERTERS	3	0	0	3

Category: Professional elective

a. Preamble

This course introduces the various power converters for the application of Power Systems.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the operation of various AC-DC converters	K2
CO2	Experiment with the various PWM techniques in inverter	K3
CO3	Identify the applications of AC-DC-AC converters	K3
CO4	Develop the concept of various DC-DC converters	K3
CO5	Select the various modern power converters for electrical power system	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

AC-DC CONVERTERS **9**

Single Phase AC - DC Converter, Three Phase AC - DC Converter, continuous and discontinuous conduction mode, Simulation of AC - DC Converter, Applications: EV Charging and HVDC Transmission.

DC-AC CONVERTERS **9**

Single Phase DC - AC Converter, Three Phase DC - AC Converter, PWM Techniques, Space Vector Modulation Techniques, Simulation of DC - AC Converter, Applications: Solar PV Systems and FACTS.

AC - DC - AC CONVERTERS **9**

Introduction to AC-DC-AC Converter, Principle of operation of single phase and Three Phase AC-DC-AC Converter, Simulation of AC - DC - AC Converter, Applications: Wind Energy Systems and Power Conditioners.

DC to DC CONVERTERS **9**

DC Choppers, Types of DC Choppers, Control Strategies of chopper, Principle of operation of BOOST Converter, BUCK Converter, BUCK - BOOST Converter and SEPIC Converter, Simulation of DC Choppers, Applications: Solar PV MPPT, EV Battery Management Systems.

MODERN POWER CONVERTERS **9**

Multilevel concept - diode clamped - flying capacitor - cascaded type multilevel inverters Comparison of multilevel inverters - application of multilevel inverters, Matrix Converters, Cuk converter, Luo converter, Voltage-Fed Z-source inverters.

d. Activities

Students shall be exposed to the advanced power converters through powerhouse of the institution.

e. Learning Resources

Text Books

1. Rashid, M.H., *Power Electronics Circuits, Devices, and Applications*, 3rd Edition, Pearson Education, 2004.
2. Jai P. Agrawal, *Power Electronics Systems*, 2nd Edition, Pearson Education, 2002.

Reference Books

1. Bose, B.K., *Modern power electronics and AC drives (Vol. 123)*, Upper Saddle River, NJ: Prentice hall, 2002.
2. Undeland, M.N., Robbins, W.P. and Mohan, N., *Power Electronics. In Converters, Applications, and Design*, John Wiley & Sons, 1995
3. Philip T. krein, *Elements of Power Electronics*, Oxford University Press, 1998.
4. Sen, P.C., *Modern power electronics*, S. Chand Publishing, 2005
5. Bimbhra, D.P., *Power Electronics*, 11th Edition, Khanna Publishers, 2003.
6. Wu, B. and Narimani, M., *High-power converters and AC drives*, John Wiley & Sons, 2017.
7. Hart, D.W., *Power electronics*, Tata McGraw-Hill Education, 2011.

Course Code	Course Name	L	T	P	C
PS1138	DIGITAL CONTROLLERS FOR POWER ELECTRONICS	3	0	0	3

Category: Professional core

a. Preamble

This course introduces the various types of power electronic devices and converter circuits including modeling, analysis and design concepts.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the specific DSP architecture and programming concepts.	K2
CO2	Illustrate the sampling of real time signal, PWM strategies and their processing in digital domain.	K2
CO3	Design of DSP based controllers for electrical machines and power electronics converters	K3
CO4	Apply digital controllers for electrical machines and power electronics converters	K3
CO5	Apply various digital control schemes of power electronics converters and drives Interfacing of power electronic systems to DSP.	K3

C. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION TO DSP AND MICROCONTROLLERS 9

Introduction to DSP and Microcontrollers - Introduction to the C2xx DSP core and code generation. The components of the C2xx DSP core, Peripherals and Peripheral Interface, System configuration registers, Memory, Types of Physical Memory, memory Addressing Modes - Application to power electronic conversion.

SAMPLING AND PWM TECHNIQUES FOR DIGITAL CONTROLLER 9

Brief introduction to Laplace transform, Theory of sampling, z transformations, sampling techniques in power electronic converters - Signal analysis, Realization of different PWM's using DSP's, Simulation of Digital PWM generation using MATLAB.

DSP BASED CONTROLLER FOR ELECTRICAL MACHINES **9**

DSP -based implementation of DC-DC buckboost converter - DSP-based control of permanent magnet brushless DC machines - DSP - based Implementation of clarkes's and park's transformations - DSP - Based implementation of SPWM, SVPWM inverter pulse generation.

DIGITAL CONTROLLER FOR ELECTRICAL MACHINES USING MATLAB **9**

Estimation of Permanent Magnet Synchronous Motor Parameters using Parameter Estimation Blocks, Design of Sensorless Field - Oriented Control of PMSM - Design of PI controller for speed regulation of Brushless DC motor drive and Speed control of switched reluctance motor.

DIGITAL CONTROL TECHNIQUES AND COMPENSATOR FOR POWER CONVERTER APPLICATIONS **9**

Implementation for IoT based DC-DC Converters and Inverters - Control Block of Power Converters - Mapping of s-domain to Z domain Euler's-Tustin's and Pre-warping techniques using MATLAB.

d. Activities

Students shall be exposed to the DSP architecture and programming concepts and design of digital controllers for power electronics applications and electrical machines.

e. Learning Resources

Text Books

1. Richard C. Dorf and Robert H. Bishop., *Modern Control Systems*, Pearson publications, 2022.
2. *TMS320C28x CPU and Instruction Set*, Reference Guide - SPRU430, Texas Instruments, 2015.
3. Irfan Turk., *MATLAB Programming for Beginners and Professionals*, Createspace, 2018.

Reference Books

1. Robert W. Erickson, Dragan Maksimovic., *Fundamentals of Power Electronics, Springer Nature, 2020.*
2. Charles Phillips, H. Nagle, Aranya Chakrabortty ., *Digital Control System Analysis and Design,Pearson Prentice Hall, 2014.*
3. Steven Smith., *Digital Signal Processing: A Practical Guide for Engineers and Scientists*, Newnes, 2002.
4. Bimbhra.P.S.,*Electrical Machinery*, Khanna publications, 2021.
5. Hamid.A.Toliyat and Steven G.Campbell., *DSP Based Electro Mechanical Motion Control*, CRC Press, New York, 2004.

Course Code	Course Name	L	T	P	C
PS1139	PRINCIPLES OF ELECTRICAL SAFETY AND MANAGEMENT	3	0	0	3

Category: Open Elective

a. Preamble

This course introduces the various electrical hazards and its protection techniques

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the statutory requirements related to electrical safety.	K2
CO2	Explain the basic concepts in usage of electricity and hazards involved in it.	K2
CO3	Describe the operation of various protection systems and types of personal protective equipment.	K3
CO4	Recognize different hazardous zones in Industries and work permit system.	K3
CO5	Describe the importance of safety education and carry out safety audit.	K3

TOTAL: 45 PERIODS

c. Course Syllabus

INTRODUCTION **9**

Introduction - current, voltage, resistance, electrostatics, electro magnetism, stored energy, energy radiation - Ionizing and Non-ionizing radiation - Electromagnetic interference - Indian Electricity act and rules - statutory requirements from electrical inspectorate.

ELECTRICAL HAZARDS **9**

Primary and secondary hazards - shocks, burns, scalds, falls - Human safety in the use of electricity - Classes of insulation - voltage classifications - current surges - over current and short circuit current - heating effects of current - electrical causes of fire and explosion - First aid - cardio pulmonary resuscitation (CPR).

PROTECTION SYSTEMS **9**

Fuse, circuit breakers and overload relays - protection against over voltage and under voltage - safe limits of amperage - voltage - safe distance from lines - overload and short circuit protection. Earth leakage circuit breaker (ELCB) - Lightning hazards, lightning arrestor, installation - earthing, specifications, earth resistance, earth pit maintenance - Personal protective equipment.

HAZARDOUS ZONES **9**

Classification of hazardous zones - intrinsically safe and explosion proof electrical apparatus - increase safe equipment - their selection for different zones-temperature classification- use of barriers and isolator - Permit to work.

SAFETY MANAGEMENT **9**

Importance of safety education and training-identification of training needs-training methods - programmes, seminars, conferences, competitions - Components of safety audit, types of audit, audit methodology, non-conformity reporting (NCR), audit checklist and report - review of inspection and maintenance of safety records safety committee-roles and responsibilities.

d. Activities

Students shall be exposed to the knowledge of fundamentals of safety management and first aid.

e. Learning Resources

Text Book

1. Rao.S, 2012 *Electrical Safety Fire Safety Engineering and Safety Management*, Khanna Publications, 2nd Edition.

Reference Books

1. Fordham-Cooper, W., 1998. *Electrical safety engineering*. Elsevier.
2. Thakur, T., Deshmukh, S.G., Kaushik, S.C. and Kulshrestha, M., 2005. Impact assessment of the Electricity Act 2003 on the Indian power sector. *Energy Policy*, *33*(9), pp.1187-1198.
3. Power Engineers – Handbook of TNEB, Chennai, 2009.

Course Code	Course Name	L	T	P	C
PS1140	RESEARCH METHODOLOGY	3	0	0	3

Category: Special Elective

e. Preamble

To impart knowledge and skills required for research

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Differentiate between Applied and Basic Research	K3
CO2	Summarize the advantages and disadvantages of each type of experiment in various research contexts.	K2
CO3	Analyze various data collection methods and capable of designing effective questionnaires	K3
CO4	Apply data analysis techniques to real-world research problems and datasets	K4
CO5	Prepare well-structured written reports that effectively communicate information, analysis, and recommendations	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION TO RESEARCH **9**

The hallmarks of scientific research - Building blocks of science in research - Concept of Applied and Basic research - Quantitative and Qualitative Research Techniques - Need for theoretical frame work - Hypothesis development - Hypothesis testing with quantitative data. Research design - Purpose of the study: Exploratory, Descriptive, Hypothesis Testing.

EXPERIMENTAL DESIGN **9**

Laboratory and the Field Experiment - Internal and External Validity - Factors affecting Internal validity. Measurement of variables - Scales and measurements of variables. Developing scales - Rating scale and attitudinal scales - Validity testing of scales - Reliability concept in scales being developed - Stability Measures.

DATA COLLECTION METHODS **9**

Interviewing, Questionnaires, etc., Secondary sources of data collection. Guidelines for Questionnaire Design - Electronic Questionnaire Design and Surveys. Special Data Sources: Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data - Collection Methods and their utility. Sampling Techniques - Probabilistic and non probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size.

MULTIVARIATE STATISTICAL TECHNIQUES **9**

Data Analysis - Factor Analysis - Cluster Analysis - Discriminant Analysis - Multiple Regression and Correlation - Canonical Correlation - Application of Statistical (SPSS) Software Package in Research.

RESEARCH REPORT **9**

Purpose of the written report - Concept of audience - Basics of written reports. Integral parts of a report - Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report - Experimental, Results and Discussion - Recommendations and Implementation section - Conclusions and Scope for future work.

d. Learning Resources

Text Books

1. Donald, R., Cooper and Ramcis, S. Schindler, *Business Research Methods*, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000.
2. Sekaran, U., *Research Methods for Business*. John Willey & Sons, Inc. New York. 2000.

Reference Books

1. McBurney, D.H., *Research Methods*, Thomson Asia Pvt. Ltd. Singapore. 2002.
2. Kumar, R., *Research methodology: A step-by-step guide for beginners*. SAGE Publications, 2018.

Course Code	Course Name	L	T	P	C
PS1141	SUSTAINABLE ENERGY CONVERSION SYSTEMS	3	0	0	3

Category: Professional elective

a. Preamble

This course introduces the various renewable based conversion systems like Solar Photo-Voltaic Conversion System and Wind Energy Conversion System.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the concept of modeling and analysis of PV cells.	K2
CO2	Make use of the standalone PV system for a typical application.	K3
CO3	Identify the design issues in grid connected PV system.	K3
CO4	Develop the mathematical modeling and controlling techniques of the wind turbine.	K3
CO5	Solve the grid integration issues and implement the current practices of wind interconnections with power system.	K3

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION **9**

Characteristics of sunlight - semiconductors and P-N junctions - behavior of solar cells - cell properties - PV cell interconnection, modeling of PV cells, Partial Shading in PV, Bypass Diode and Blocking Diode Application, Components of WECS - WECS schemes, Modeling of Solar PV module.

STAND ALONE PV SYSTEM **9**

Solar modules - storage systems - power conditioning and regulation - MPPT (P&O and IC Methods) - protection - standalone PV systems design - sizing of solar system for 5 HP motor pump, Simulation of stand-alone PV system.

GRID CONNECTED PV SYSTEMS **9**

PV systems in buildings - design issues for central power stations - safety - Economic aspect - Efficiency and performance - International PV programs, Simulation of grid connected PV system.

WIND TURBINES **9**

HAWT - VAWT - Power Developed - Thrust - Efficiency - Rotor Selection - Rotor design considerations - Tip speed ratio - No. of Blades-Blade profile-Power Regulation - yaw control - Pitch angle control - stall control - Schemes for maximum power extraction, Modeling of Wind Generator

GRID CONNECTED WIND ENERGY SYSTEMS **9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue, Simulation of grid connected wind energy system

d. Activities

Students shall be exposed to the basic renewable based conversion systems through the real time exposure in the academic D-block.

e. Learning Resources

Text Books

1. Solanki, C.S., *Solar photovoltaics: fundamentals, technologies and applications*, PHI Learning Pvt. Ltd., 2015.
2. John, W. and Nicholas, J., *Wind energy technology*, New York: John Wiley and Sons Inc., 1997.

Reference Books

1. Wenham, S.R., *Applied photovoltaics*, Routledge, 2011.
2. Lorenzo, E., *Solar electricity: engineering of photovoltaic systems*, Earthscan / James & James, 1994.
3. Barnes, F.S. and Levine, J.G. eds., *Large energy storage systems handbook*, CRC press, 2011.
4. McNeils, Frenkel, Desai, *Solar & Wind Energy Technologies*, Wiley Eastern, 1990.
5. Sukhatme, S.P. and Nayak, J.K., *Solar energy*, McGraw-Hill Education, 2017.
6. Heir, S., *Grid Integration of WECS*, 1998.
7. Freris, L.L. and Freris, L.L. eds., *Wind energy conversion systems (Vol. 31)*, New York : Prentice Hall, 1990.

8. Bhadra, S.N, Kastha,D, Banerjee,S., *Wind Electrical Systems*, Oxford University Press, 2010.
9. Ion Boldea, *Variable speed generators*, Taylor & Francis group, 2006.
10. Golding, E.W. and Harris, R.I., *The generation of electricity by wind power*, London: E. & FN Spon, 1976.

Course Code	Course Name	L	T	P	C
MF1135	COMPOSITE TECHNOLOGY	3	0	0	3

OBJECTIVES:

- To impart knowledge of various types of composites and its advantages and needs.
- To understand the various types of fiber materials and its applications for making Composites.
- To understand the knowledge of various resins materials used in processing of composites and the basic destructive and non-destructive testing of composites.

INTRODUCTION AND MATRIX FOR COMPOSITES **9**

Introduction - Characteristics of composites - Classification - Based on matrix - PMC - MMC - CMC - Reinforcement - particulate, fibrous, laminated, and hybrid composites. Matrix Resins - Unsaturated Polyester - Vinyl Ester - Epoxy - Thermoset polyimides - Bismaleimides (BMIs), Cyanate esters (CEs), Benzoxazines and Phthalonitriles- Preparation - Properties and Applications.

REINFORCEMENT MATERIALS **9**

Fibre Reinforcements - Types - CSM - Surface Mats - Performs - Woven and Non Woven Fabrics - Glass - Carbon - Aramid Fibre - Boron Fibres - Natural Fibres - Cotton - Silk - Wool - Jute - Sisal- Functions of fillers, types, properties, chemistry and applications of fillers such as silica, titanium oxide, talc, mica, silicon carbide, graphite.

PROCESSING OF COMPOSITES **9**

Processing of thermoplastic composites - Types of processing methods, matched die molding, solution, film, lamination, sandwich. Processing conditions, advantages and disadvantages**.**

Fabrications of thermoset composites - Hand lay up method, match die molding, compression and transfer molding, pressure and vacuum bag process, filament winding, pultrusion, RIM, RRIM, VARTM & VERTM, Injection moulding of thermosets, SMC and DMC, Advantages and disadvantages of each method.

TESTING AND APPLICATION OF COMPOSITES **9**

Testing of Composites - Tensile, Impact, Compression and Flexural Strength - Non Destructive testing for Composites - Application of FRP Products - Products in Aerospace - Marine - Electrical and Electronics - Biomedical - Automobile Industries.

LAMINATES FOR COMPOSITES **9**

Mechanics of composites - Mechanism of reinforcement and fibre / matrix adhesion - Fracture and damage mechanics - laminates - delamination - Design consideration - sandwich structures - Measurement of physical and mechanical properties: density - fibre volume fraction - void content fibre / matrix interface test.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1. Apply the knowledge of matrix resins in making of composites

CO2. Select suitable fibre reinforcement for composite.

CO3. Apply the knowledge of composite processing and fabrication

CO4. Test the composites and usage of composites for various applications

CO5. Demonstrate the lamination process in composites manufacturing.

REFERENCES:

1. Astrom, B.T., 1997. *Manufacturing of polymer composites*. CRC press.
2. Hollaway, L.C. ed., 1994. *Handbook of polymer composites for engineers*. Woodhead publishing.
3. Hinton, M.J.K.A., Soden, P.D. and Kaddour, A.S. eds., 2004. *Failure criteria in fibre reinforced polymer composites: the world-wide failure exercise*. Elsevier.
4. Peters, S.T. ed., 2013. *Handbook of composites*. Springer Science & Business Media.

Course Code	Course Name	L	T	P	C
MF1136	FUNDAMENTALS OF ADDITIVE MANUFACTURING TECHNIQUES	3	0	0	3

Category:

a. Preamble

This course is not merely a subject; it is a gateway to the future of manufacturing. Welcome to a world where ideas materialize layer by layer, and innovation knows no bounds. By the end of this course, students will not only have acquired a comprehensive understanding of additive manufacturing but will also be equipped with the knowledge and skills to harness this transformative technology to innovate and solve real-world problems.

e. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the various materials used in the Additive Manufacturing techniques.	K2
CO2	Know the usage of CAD Modelling and slicing software for Additive Manufacturing techniques.	K2
CO3	Explain the principle and process of Polymer-based Additive Manufacturing techniques.	K2
CO4	Discuss the principle and process of Metal-based Additive Manufacturing techniques.	K2
CO5	Recognize the elements of Design for Additive Manufacturing.	K2

c. Course Syllabus **TOTAL : 45 PERIODS**

INTRODUCTION **9**

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes. Polymers, Metals, Non-Metals, Ceramics - Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, FGM - Composite Materials in AM.

CAD Modelling **9**

CAD Modelling for 3D printing: 3D Scanning and digitization - data handling &reduction Methods - AM Software: data formats and standardization - Slicing algorithms : uniform flat

layer slicing - adaptive slicing - Process-path generation : Process - path algorithms - rasterization - part Orientation - support generation.

POLYMER ADDITIVE MANUFACTURING **9**

Stereo - Lithography, LOM, FDM, SLS, Binder Jet technology - Process, Process parameter, Process Selection for various applications- Defects and their causes - Inspection and Testing of polymer - based AM.

METAL ADDITIVE MANUFATURING **9**

Selective Laser Melting (SLM), Laser Beam Melting (LBM), Laser Metal Fusion (LMF), Direct Metal Laser Sintering (DMLS), Electron Beam melting (EBM), Laser Cladding, Directed Energy Deposition and Laser Metal Deposition Process, Laser Engineered Net Shaping (LENS), Wire Arc AM, Friction Stir AM - Inspection and Testing metal AM.

DESIGN FOR ADDITIVE MANUFACTURING **9**

AM technology selection - Build strategies - Minimum feature size - Surface finish - Elimination of support structures - Guidelines for internal geometry like flow paths, cooling channels, cavities and others - Guidelines for making lightweight objects - Guidelines for making functionally gradient objects - DfAM : Process specific strategies, Rules and Recommendations

d. Activities

Students shall be exposed to learn additive manufacturing techniques through laboratory practical demo.

e. Learning Resources

Text Books

1. Ian Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer 2010
2. Soloman S “3D Printing and Design”, Khanna Publishing House, Delhi, 2020.

Reference Books

1. Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing”, Hanser Publisher, 2011
2. CK Chua, Kah Fai Leong, “3D Printing and Rapid Prototyping Principles and Applications” World Scientific, 2018.
3. J.D. Majumdar and I. Manna, “Laser-Assisted Fabrication of Materials”, Springer Series in Material Science, 2013.

Course Code	Course Name	L	T	P	C
MF1137	MATERIAL TESTING AND CHARACTERIZATION TECHNIQUES	3	0	0	3

Category: Elective Course

a. Preamble

Material testing is essential for determining the properties and behavior of materials under various conditions, ensuring their suitability for specific applications. At the end of this course, students can assess the characteristics of materials such as strength, durability, and performance to meet industry standards and requirements.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	To provide an understanding of techniques of microstructure and crystal structure evaluation of materials	K2
CO2	To introduce tools for analysis of microstructure and surface topography of materials	K2
CO3	To understand the techniques of chemical and thermal analysis of materials.	K2
CO4	To gain knowledge in various static mechanical testing methods.	K2
CO5	To gain knowledge in various dynamic mechanical testing methods	K2

c. Course Syllabus **Total : 45 Periods**

MICRO AND CRYSTAL STRUCTURE ANALYSIS **9**

Principles of Optical Microscopy - Specimen Preparation Techniques - Polishing and Etching - Polarization Techniques - Quantitative Metallography - Estimation of grain size - ASTM grain size numbers - Microstructure of Engineering Materials - Elements of Crystallography - X- ray Diffraction - Bragg's law - Techniques of X-ray Crystallography - Debye - Scherer camera - Geiger Diffractometer - analysis of Diffraction patterns - Inter planer spacing - Identification of Crystal Structure, Elements of Electron Diffraction.

ELECTRON MICROSCOPY **9**

Interaction of Electron Beam with Materials - Transmission Electron Microscopy - Specimen Preparation - Imaging Techniques - BF & DF - SAD - Electron Probe Microanalysis -

Scanning Electron Microscopy - Construction & working of SEM - various Imaging Techniques - Applications Atomic Force Microscopy - Construction & working of AFM - Applications.

CHEMICAL AND THERMAL ANALYSIS **9**

Basic Principles, Practice and Applications of X-Ray Spectrometry, Wave Dispersive X-Ray Spectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo Gravity metric Analysis (TGA)

MECHANICAL TESTING - STATIC TESTS **9**

Hardness - Brinell, Vickers, Rockwell and Micro Hardness Test - Tensile Test - Stress - Strain plot - Proof Stress - Torsion Test - Ductility Measurement - Impact Test - Charpy & Izod - DWTT - Fracture Toughness Test, Codes and standards for testing metallic and composite materials

MECHANICAL TESTING - DYNAMIC TESTS **9**

Fatigue - Low & High Cycle Fatigues - Rotating Beam & Plate Bending HCF tests - SN curve - LCF tests - Crack Growth studies - Creep Tests - LM parameters - AE Tests-modal analysis - Applications of Dynamic Tests.

d. Activities

Students shall be given hands-on experience with various material testing equipments (tensile test, impact test, hardness test, torsion test, and bend test) within the college premises.

e. Learning Resources

Text Books

1. Baldev Raj, Jayakumar T, Thavasimuthu M, *Practical Non-Destructive Testing*, Narosa Publishing House, 2009.
2. Cullity, B. D., Elements of X-ray diffraction, 3rd Edition, Addison-Wesley Company Inc. New York, 2000.
3. Field Foster P, The Mechanical Testing of Metals and Alloys, 7th Edition, Cousens Press, 2007.
4. Goldsten, I.J., Dale.E., Echin. N.P.& Joy D.C., *Scanning Electron Microscopy & X-ray- Micro Analysis*, 2nd Edition, Plenum Publishing Corp, 2000.

Reference Books

1. *Metals Handbook: Mechanical testing, (Volume 8)* ASM Handbook Committee, 9th Edition, American Society for Metals, 1978.
2. ASM Metals Handbook, *Non-Destructive Evaluation and Quality Control*, American Society of Metals, Metals Park, Ohio, USA.
3. Brandon D.G., *Modern Techniques in Metallography*, Von Nostrand Inc. NJ, USA, 1986.
4. Grundy P.J. and Jones G.A, *Electron Microscopy in the Study of Materials*, Edward Arnold Limited, 1970