Subject Code	OE2E01	**Course Title**	**Introduction to Sensors & Actuators**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	B.Tech./ BDes.	**Semester**	III
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Attendance (5%),Mid Term (15%), Quiz(10%), End term (50%), Practical (20%)		

Detailed Course Content

1. Introduction: Classification of sensors and actuators, sensing and actuating strategies, general requirements for interfacing and actuation, sensing, transduction, and actuation.	**[02H]**
2. Performance Characteristics of Sensors and Actuators: Input/output characteristics, accuracy, errors, repeatability, sensitivity analysis, hysteresis, Nonlinearity, saturation, frequency response, dynamic characteristics, calibration, resolution, excitation, impedance, applications.	**[03H]**
3. Temperature Sensors and Thermal Actuators: Thermoresistive sensors: Thermistors, Resistance temperature sensors, Silicon resistive sensors, Thermoelectric sensors, PN junction temperature sensors, and Optical and acoustic temperature sensors.	**[04H]**
4. Optical sensors: Photodiodes, phototransistors and photoresistors based sensors, Photomultipliers, light- to-light detectors, infrared sensors (thermal, PIR, AFIR, thermopiles), CCD sensors and detectors.	**[04H]**
5. Electric and Magnetic Sensors and Actuators: Motors as actuators (linear, rotational, stepping motors), magnetic valves, inductive sensors (eddy current, LVDT, RVDT, Proximity), Hall Effect sensors, Magnetohydrodynamic (MHD) Sensors and Actuators Voice coil actuators (speakers and speaker-like actuators), Motors as Actuators Magnetic Solenoid Actuators and Magnetic Valves, Voltage and Current Sensors.	**[05H]**
6. Mechanical Sensors and Actuators: Accelerometers (capacitive, piezoelectric, piezoresistive, thermal), Force sensors (strain gauges, tactile sensors), Pressure sensors (semiconductor, piezoresistive, capacitive, VRP), Gyroscopes (mechanical, optical, fiber-optics).	**[03H]**
7. Chemical Sensors and Actuators: Electrochemical Sensors, Potentiometric Sensors Thermochemical Sensors Optical Chemical Sensors Mass Sensors Humidity, and Moisture Sensors Chemical Actuation.	**[04H]**
8. MEMs Sensors and Actuators: Micro-Electro-Mechanical (MEMs) Sensors (pressure, mass, inertia, angular rate sensors) and Actuators (applications).	**[03H]**
9. Other Sensors and Actuators: Radiation Sensors and Actuators, Acoustic Sensors and Actuators, Smart Sensors and Actuators	**[03H]**
10. Interfacing Methods and Circuits: Amplifiers: operational amplifiers, power amplifiers, A/D and D/A converters, bridge circuits, interfacing to microprocessors, data transmission, excitation methods and circuits, Power requirements, signal translation, isolation, noise, interference, compensation (Temperature, drift, etc.).	**[04H]**

Text/Reference books:

1. Ida, N., Sensors, Actuators, and their Interfaces; Scitech Publishing
2. deSilva, Sensors and Actuators: Control System Instrumentation, CRC Press

Subject Code	EC8035	**Course Title**	**Wireless Communications**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech.	**Semester**	VII
Pre-requisites		**Mode Core/Elective/EMF**	Elective

Evaluation scheme	Mid Term 30 marks, Quiz 1 & 2 :15 marks each, End term : 40 marks OR Quiz 1 & 2 :10 marks each, Mid Term 20 marks, End term : 40 marks , Project : 20 marks

Detailed Course Content

VIII. Learning Objective: To understand the wireless channels, technical issues, and solutions techniques for the same.

IX. Detailed Course Content:

Module1: Review of Digital Communication: Block diagram of digital communication, Modulation Schemes, Pulse Shaping, Bandwidth efficiency, MAP-Receivers, AWGN Channel and Performance analysis; Fundamental capacity of wireless channels	10 H
Module2: Wireless Channel Models: Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, RMS Delay Spread, Impact of Doppler Fading, Doppler Fading, BER Performance in Fading Channels, Capacity and Outage. Diversity modeling for Wireless Communications, BER Performance Improvement with diversity, Types of Diversity – Frequency, Time, Space.	10 H
Module3: Spread spectrum communication and CDMA, Walsh codes, PN Sequences, Multipath diversity, RAKE Receiver. Multi-input multi-output (MIMO) antenna systems: Introduction to MIMO, MIMO Channel Capacity, SVD and Eigenmodes of the MIMO Channel, MIMO Spatial Multiplexing – BLAST, MIMO Diversity –Space-time block codes, Alamouti, OSTBC.	10 H
Module4: Multicarrier Modulation systems and orthogonal frequency division multiplexing (OFDM), Wireless Standards and advanced topics.	10 H

Text/Reference books:

1. *D. Tse and P. Viswanath, "Fundamentals of Wireless Communications," Cambridge University Press, 2005.*

2. *A. Goldsmith, "Wireless Communications," Cambridge University Press, 2005.*

3. *T. S. Rappaport, "Wireless Communications: Principles and Practice," 2nd Ed., Prentice Hall.*

Subject Code	OE4E73	**Course Title**	**Statistical Signal Processing**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech/ MTech	**Semester**	VII
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz I & II : 15 each, Mid Sem 30, End Sem:40		

VIII. Learning Objective: To provide a broad and coherent treatment of statistical signal processing concepts, techniques and algorithms, namely for discrete-time signal modeling, optimum estimation and filtering, and power spectrum estimation. These tools are general for applications dealing with information extraction in scenarios governed by random processes and probabilistic models.

IX. Prerequisites for this course: **Probability Theory Basics**

X. Detailed Course Contents:

Module1: **Review of Discrete-Time Signal Processing**: Discrete-time signals and systems, time-domain description of LSI filters, the discrete-time Fourier transform, the z-transform, special classes of filters, filter flowgraphs, the DFT & FFT. **Review of Random Variables:** Distribution and density functions, independent, uncorrelated and orthogonal random variables, orthogonality principle in estimation, central limit theorem, random process, stationary process, autocorrelation & autocovariance functions, spectral representation of random signals, Wiener Khinchin theorem, properties of PSD, Gaussian process & White noise process	08 H
Module2: Linear system with random input, spectral factorization theorem, innovation process and whitening filter, random signal modelling: MA(q), AR(p), ARMA(p,q) models	06 H
Module3: **Parameter Estimation Theory:** Principle of estimation and applications, properties of estimates, unbiased & consistent estimators, Linear MMSE estimation, Bayes estimation, Maximum Likelihood Estimation	06 H
Module4: **Optimum Linear Filters:** The Wiener Approach – Wiener Hoff Equation, FIR Wiener Filter, Causal IIR Wiener Filter, Noncausal IIR Wiener Filter	06 H

Module 5: **Adaptive Filtering:** Principle and applications, steepest descent algorithm, convergence characteristics, LMS algorithm, convergence, RLS algorithm	06 H
Module 6 : **Spectrum Estimation:** Nonparametric Methods – The Periodogram, Performance of the Periodogram, The Modified Periodogram, Bartlett's Method, Welch's Method, Blackman-Tukey Approach Parametric Methods – Autoregressive Spectrum Estimation, Moving Average Spectrum Estimation, Autoregressive Moving Average Spectrum Estimation	08 H

Text/Reference books:

1. Statistical Digital Signal Processing and Modelling - Monson H.Hayes, Wiley
2. Random Processes – Filtering, Estimation & Detection – Lonnie C. Ludeman, Wiley
3. Fundamentals of Statistical Signal Processing, Volume III: Practical Algorithm Development (Prentice-Hall Signal Processing Series)- Steven M.Kay
4. Modern Spectral Estimation (Theory & application) - Steven M.Kay, Pearson

Subject Code	OE4M76	**Course Title**	**Digital Twins in Manufacturing**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	UG and PG	**Semester**	VII
Pre-requisites			
Evaluation scheme	Quiz/ Assignment:15%,/ Mid Term:15%, End Term:40%, Lab:15%, Project:15%, Corse Project: 15%		

VIII. Learning Objective:

- To acquaint the students with the basic concept of Digital Twins in the context of advanced manufacturing
- Practicing virtual design and commissioning of a factory layout.
- To train students with the application of Digital Twins in modeling and optimizing real-life industrial problems.

Detailed Course Content:

Module 1 INDUSTRY 4.0: Introduction to Industry 4.0, Technologies drivers & enablers of industry 4.0, like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics	02 H
Module 2 Overview of enabling technologies for Digital Twin like Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Big Data Analytics, Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Cloud Computing Services (CCS), etc.	04 H
Module 3 What is Digital Twin, Basic concepts, applications, opportunities, and challenges influencing digital twin, Growth drivers for digital twin, Future research areas of digital twin, Careers in Digital twin, Digital Twin Engineer Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial Digital Twin, Clone Digital Twin, Augmented Digital Twin (ADT), Smart & Connected design, accelerating industry 4.0 using Digital Twin	07 H
Module 4 How to build a digital Twin, Steps in building a Digital Twin Data processing: Collection, review, cleaning, transformation of data and cloud database maintenance. Simulation: Field data simulation created by automated processes in the cloud database. Inverse modeling: Gathering information on the model and its parameters from (historical)	10 H

measurements of the subject. Data to IIoT integration: mimicking Digital Twin with real-world asset, Calibrate the Digital Twin and uncertainty. Working with a Digital Twin, Digital Twin Platforms, Concurrent engineering	
Module 5: Use cases of Digital Twin in Product development, Logistics Manufacturing, Simulation, Predictive Maintenance, Asset Maintenance, Health Care & etc.	02 H
Module 6: Integration of Digital Twin with Product Life Cycle Management (PLM), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management (SRM), Manufacturing Execution Systems (MES) etc. Benefits of Digital Twins	03 H
Lab Experiments: 1. Software familiarization 2. Data Processing, Data representation and visualization 3. Develop Digital twin of Lathe machine 4. Study of influencing parameters 5. Develop a digital twin of a mini factory 6. Optimizing the process affecting the production 7. Mini Project I 8. Mini Project II 9. Mini Project III 10. Mini Project IV	

Text and Reference Books:

1.	Digital Twin: Possibilities of the new Digital twin technology, Anand Iyer, 2017, 35 Pages
2	Digital Twin Development & Deployment on the Cloud, Ist edition, Nassim Khaled Bibin Pattel AffanSiddiqu, ISBN: 9780128216316, ELSEVIER, pages 592
3.	Digital Twin Technologies & Smart Cities, Maryam Farsi, Alireza Daneshkhah, Amin Hosseinian-Far, Hamid Jahankahani, Springer, ISBN 978-3-030-18731-6
4.	Groover, Automation, Production System, Computer Integrated Manufacturing, Pearson Publishing
5.	Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee, ISBN 978-0-12-817630-6, ELSEVIER, pages 257
6.	Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj & Preetha Evanjaline, ELSEVIER, pages 257, ISBN 978-0-12-818756-2, ISSN 0065-2458
7.	Different research papers

Subject Code	OE2M10	Course Title	Energy System Design
Contact Hours	L-3, T-0, P-0	Credit	3
Programme	Open Elective for UG	Semester	III
Pre-requisites		Mode Core/Elective/EMF	Open Elective
Evaluation scheme	Quiz:10%, Assignment:10%, Mid Term:30%; End Sem:50%,		

VIII. Learning Objective:

- To provide knowledge, understanding and application-oriented skills on conventional and non-conventional sources of energy and relevant technologies towards their effective utilization for meeting energy demand.
- To understand the present scenario for energy conservation and utilization of renewable energy sources for both domestic and industrial applications.
- To impart knowledge on market parameters governing economic analysis and energy conservation.
- To provide a broad overview of the technology covering aspects of wind energy conversion systems.
- To understand the fundamentals of a solar cell.

IX. Course Outcomes: After completion of this course students will be able to

- ✓ Know the need of energy resources, historical and latest developments.
- ✓ To gain knowledge on market parameters governing economic analysis and energy conservation.
- ✓ To gain knowledge on regional and national level energy policies.
- ✓ Conduct a basic wind resource estimation and site assessment.
- ✓ Understand the fundamentals of wind turbine design, characteristics and operation.
- ✓ Understand the principle of direct solar energy conversion to electric power using PV technology
- ✓ Understand various storage technologies.

Detailed Course Content:

Module 1: ***Introduction*** Energy and development, units and measurement, conventional and non-conventional sources of energy, fossil, non-fossil and renewable energy resources, Importance of electrical energy in modern industrial society, Usefulness, advantages and disadvantages of energy sources and need of alternative energy sources. **Economics and Planning of Energy Systems:** Introduction: Law of demand, Elasticities of demand, Theory of firm: Production function, output maximization, cost minimization and profit maximization principles. Theory of market, National income and other macroeconomic	10 H

parameters, Basic concepts of Energy Economics, Socio-economic evaluation of Energy Conservation Programmes, Overview of Energy Policies.	
Module 2: ***Different Source of Energy*** **Wind Energy Systems:** Wind Energy Fundamentals, Wind Energy Basics, Wind Speeds and Scales, Terrain, Roughness, Site Selection, Principles ofAerodynamics of wind turbine blade, Power Content, Betz's Limit, Instrumentation for wind measurements, Wind data analysis, Wind resource estimation, Vertical and Horizontal Axis Wind Turbine, Horizontal Axis, Torque-Speed and Power-Speed Characteristics of Wind Turbines, Wind Turbine Control Systems: Pitch Angle Control, Stall Control, Yaw Control and Control strategy. **Hydro Energy Systems:** Hydro energy fundamentals and basics, Micro and mini hydropower system, Horizontal and vertical axis current turbine, Tidal and wave energies. **Solar Cell Fundamentals:** Photovoltaic effect: Principle of direct solar energy conversion into electricity in a solar cell. Solar cells, modules and arrays, fill factor, efficiency, Solar PV modules: series and parallel connection of cells, mismatch in cell/module, mismatch series and parallel connections, commercial solar cells PV Modelling: Equivalent circuit of PV cell, output characteristics, Double and single diode models, from data sheet values to model parameters, PV module equivalent parameters, effect of solar irradiance, effect of temperature on PV module power output.	18 H
Module 3: ***Introduction to energy storage technology and energy storage processes:*** The need for energy storage - Types and general concepts, Energy storage processes: Electrical energy storage – Super capacitors: Fundamentals and types of super capacitors, Magnetic Energy Storage – superconducting systems, Thermal Energy Storage – phase change materials, Mechanical - Pumped hydro, Flywheels and Compressed air energy storage, Chemical - Hydrogen Storage, Production and storage alternatives, Other approaches to hydrogen storage.	08 H
Module 4: ***Energy System design & Applications:*** Energy storage for renewable energy sources, Large scale applications/ Stationary (Grid applications) – Power and energy applications, Small scale applications - Portable storage systems/medical devices, Mobile storage applications (Electric vehicles - Introduction and types of EV's, Batteries and fuel cells – future technologies), Hybrid systems for energy storage.	06 H

Text and Reference Books:

1	J. Twidell and T Weir, "Renewable energy Recources", Taylor and Francis group 2007.
2	Renewable Energy- Power for a Sustainable Future, Godfrey Boyle, Oxford University Press.
3	EA Diulio, Macroeconomic Theory, Schaum's Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)
4	R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997

5	S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford Univ. Press, New Delhi, 2005.
6	Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001.
7	Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", PHI Learning Pvt., Ltd., 2009.
8	Jha .A.R, "Solar Cell Technology and Applications", CRC Press, 2010.
9	Energy Storage - Technologies and Applications, Ed: Ahmed Faheem Zobaa, ISBN 978-953-51-0951-8, 328 pages, Publisher: InTech, 2013.
10	J. Jensen and B. Sorenson. Fundamentals of Energy Storage. Wiley-Interscience, New York (1984)

Subject Code	ME8028	**Course Title**	**Fundamentals of Signals and systems**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech/B.Des -	**Semester**	III
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Mid Sem, Two Quiz, and End Sem		

VIII. Learning Objective: Signals and systems theory has proven to be an extremely valuable tool for the past 70 years in many fields of science and engineering, including power systems, automatic control, communications, circuit design, filtering, signal processing, smart manufacturing & Mechanical Engineering.

IX. Detailed Course Content:

Module1: **Signals and Classifications:** Introduction to Signals - Continuous time and discrete time signals, Transformations of the Time Variable, Classification of Signals: Periodic, Aperiodic, One dimensional and Multidimensional signal, Even, Odd, Energy and Power signals, Deterministic and Random signals, Elementary signals: unit step, unit impulse, unit ramp, sinusoidal and complex exponential signals, Basic operations on signals for CT/DT: Multiplication by a scalar, signal addition, linear combination, signal multiplication, time shifting, time scaling, combination of time shifting and time scaling. Transformation of independent & dependent variables	8 H
Module2: **Systems and Classifications** Introduction to Systems and Classification of Systems: Continuous time, discrete time, Linear and non-linear systems, Causal, non-causal systems, Static and Dynamic, time-invariant, time-variant systems, Invertible, non-invertible, Interconnection of systems. System properties: linearity: additivity and homogeneity, Stability.	8 H
Module3: **Analysis of Linear Time Invariant Systems:** Time Domain characterization of continuous time and discrete time LTI systems, computation of impulse response, Convolution Integral, Convolution Sum, Properties of Linear Time-Invariant Systems, Signal responses to CT-LTI system, Causal LTI Systems Described by Difference Equations.	8 H
Module 4: Fourier Analysis and Applications: Fourier series representation of continuous time periodic signals, properties of continuous time Fourier series. Fourier transform of continuous time aperiodic and periodic signals - properties of continuous time Fourier transform. Fourier series representation of discrete time periodic signals - properties of discrete time Fourier series. Discrete time Fourier transform -- properties, Application to network solving.	10 H
Module 5: Laplace Analysis and Applications Definition of the Two-Sided Laplace Transform, Inverse Laplace Transform, Convergence of the Two-Sided Laplace Transform, Poles and Zeros of Rational Laplace Transforms, Properties of the Two-Sided Laplace Transform, Analysis and	8H

Characterization of LTI Systems Using the Laplace Transform, Definition of the Unilateral Laplace Transform, Properties of the Unilateral Laplace Transform, Application of Laplace Transform techniques to LTI Differential System, Analysis of LTI Differential Systems	

Text/Reference books:

1. Signals and systems / Alan V. Oppenheim,
2. Signals and Systems, Simon Haykin
3. Signals and Systems Using MATLAB, Luis F. Chaparro, University of Pittsburgh
4. Fundamentals of Signals and Systems, Benoit Boulet

Subject Code	OE4M75	**Course Title**	**Fundamentals of Tribology and Rheology**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	PhD open for M.Tech and Final year B.Tech	**Semester**	
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz/ Assignment: (30%), Mid Term:(30%), End Term:(40%),		

VIII. Learning Objective: This course has a great academic and industrial significance.

- To teach the students with the basic concept of Tribology and Rheology.
- To emphasis on the mechanisms related to Tribology and Rheology.
- To acquaint students with the application of Tribology and Rheology in various problems of Engineering.

Detailed Course Content:

Module 1: Introduction to Tribology 1. Introduction to Tribology 2. historical background; factors influencing. 3. Engineering surfaces-characterization & techniques	06 H
Module 2: Friction and Wear 1. Causes of Friction. 2. Adhesion Theory. 3. Abrasive Theory 4. Junction Growth Theory. 5. Laws of Rolling Friction. 6. Friction Instability 7. Wear Mechanisms. 8. Adhesive Wear. 9. Abrasive Wear. 10. Corrosive Wear. 11. Fretting Wear. 12. Wear Analysis	14 H
Module 3: Lubrication and Lubricants 1. Importance of Lubrication. 2. Boundary Lubrication. 3. Mixed Lubrication. 4. Full Fluid Film Lubrication ; Hydrodynamic 5. Elastohydrodynamic lubrication. 6. Types & Properties of Lubricants. 7. Lubricants Additives. 8. Application of Tribology.	06 H

Module 4: Introduction to Rheology and response functions	
1. Introduction 2. Complex fluids 3. Different types of non-Newtonian Rheological Behavior and their modeling. 4. Rheological Categorization of Complex fluids: Shear Thinning Fluids, Shear Thickening Fluids, Thixotropic Fluids, Yield Stress Fluids, Power Law fluids) 5. Various Types of Rheological Response Functions (Creep Compliance, Storage/Loss modulus, Stress Relaxation modulus, Viscosity) 6. Rheological Measurement methodology: Step Strainand Step Stress experiment, Oscillatory experiment (Frequency sweep, Amplitude sweep, time sweep).	14 H

Text and Reference Books:

1.	Dowson D, History of Tribology, Longman London, 1979
2	Michael M Khonsari, Applied Tribology (Bearing Design and Lubrication), John Wiley & Sons, 2001.
3.	Ludema K C, Friction, Wear, Lubrication: A textbook in Tribology, CRC Press, 2010
4.	Sahoo P, Engineering Tribology, PHI Learning private limited, 2005
5.	C. W. Macosko, "Rheology: Principles, Measurements, and Applications", VCH, 1994
6.	R. G. Larson, "The Structure and Rheology of Complex Fluids", Oxford UP, 1998

Subject Code	ME5029	**Course Title**	**Introduction to Non-Destructive Evaluation**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	Open For M.Tech and Final Year B.Tech	**Semester**	I
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz/ Assignment: (15%), Mid Term:(35%), End Term:(50%),		

VIII. Learning Objective:

- To provide a basic understanding of different NDE techniques and their use in various industrial and medical applications.

Detailed Course Content:

Module 1: *Liquid Penetrant Testing:* *Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - preparation of test materials- dye penetrant testing of welding.* ***Magnetic Particle Testing:*** *Theory of magnetism, inspection materials, types of test methods- wet and dry particles, magnetic particle inspection of castings, and welding.*	12 H
Module 2: Eddy Current Testing: Basics of electromagnetics - Generation of eddy currents- properties of eddy currents – eddy current sensing elements-calibration-inspection of tubes, cylinders, steel bars, welded tubing.	08 H
Module 3: Ultrasonic Testing: Nature of sound waves, wave propagation in metals– modes of sound wave generation– velocity, frequency, and wavelength of ultrasonic waves- principle of pulse-echo method and through transmission method– calibration-data presentation A, B, and C scan displays- applications in medical and industrial sector.	12 H
Module 4: Radiographic Testing: Principle of radiography, radiation sources-radiation detectors- radiographic sensitivity-penetrometers-change of mA and kV effect on "quality" and intensity of X-rays- single and double wall Radiography-applications in medical and industrial sector.	10 H

Text and Reference Books:

1.	ASM Handbook, Volume 17: Nondestructive Evaluation of Materials, ASM International (2018).
2	ASME Sec V 2001 (Boiler & Pressure Vessel Code), ASME Intl. (2017).
3.	J. L. Rose, Ultrasonic waves in solid media, Cambridge University Press, (2004).
4.	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2017).

Subject Code	SM3009	**Course Title**	**Additive and Subtractive Manufacturing Processes**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	B.Tech	**Semester**	V
Pre-requisites		**Mode Core/Elective/EMF**	Core
Evaluation scheme	Quiz I:(10%), Mid Term:(30%), Quiz II:(10%), End Term:(50%),		

VIII. Learning Objective: To explore the vast repertoire of Additive and Machining processes, ranging from traditional "crafts" to the latest technology, to enable their designs to be manufactured effectively and efficiently.

IX. Detailed Course Content:

Additive Manufacturing		
1.Introduction to Additive Manufacturing (AM)	General overview, Introduction to reverse engineering, Traditional manufacturing Vs AM, Different AM processes & file formats	03
2.Materials science for AM	Discussion on different materials used and role of solidification, Evolution of non-equilibrium Structure property relationship, Grain structure and microstructure	03
3.AM technologies	Powder-based AM processes, Solid-based AM processes Fused deposition modelling and Stereolithography	05
4. Case studies	Numerical Modelling of AM process	02
Subractive Manufacturing Processes		
1.Introduction to Machining	Geometry of cutting tools and various tool designation systems and their interrelationship, Mechanisms of chip formation and Mechanics of Machining - Orthogonal and Oblique machining Analysis of cutting forces during orthogonal machining using Merchant's circle diagram ,Various methods of determining cutting forces and temperature, Methods for controlling cutting temperature and improving surface integrity aspects during machining	03
2.Cutting Tools	Advanced tool materials and their uses, Tool wear mechanisms and tool life, measurements of tool wear	03
3. Abrasive machining processes	Basics and ultraprecision machining and grinding processes, their applications, and requirements of machine tools for ultraprecision machining	03
4. Safety considerations	Safety considerations and impact on environment of the various machining processes	02

Reference/Text Books

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.

2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
3. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.
4. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
5. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, InTech, 2012.
6. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.
7. G. Boothroyd, Fundamentals of Metal Machining and Machine Tools ,Taylor and Francis, 3rd Edition.
8. M. C. Shaw, Metal Cutting Principles,Oxford University Press
9. J.A.McGeough, Advanced Methods of Machining, Springer International Edition

Subject Code	OE3N35	**Course Title**	Advanced Scientific Numerical Methods
Contact Hours	L-3, T-0, P-0	**Credit**	4
Programme	UG & PG Students	**Semester**	I & 2
Pre-requisites	No	**Mode Core/Elective/EMF**	Open Elective
Evaluation scheme	Mid Sem(30%), End Sem(40%), Project/Quiz: (30%),		

VIII. Learning Objective: Scientific computations are an essential tool for many areas of engineering and sciences. Hence the objective of the course is to understand the intricacies of mathematical background of existing algorithms and learn some advanced scientific computational methods for obtaining numerical solutions of partial differential equations.

IX. Detailed Course Content:

Module-1: Scientific representation of numeric digits, Numerical sensitivity, source of errors, order of convergence, function approximations, curve fitting, Interpolations, piecewise interpolation, convergence analysis, error estimates, splines, B-splines	10
Module-2: , Computation methods for numerical Integration, numerical methods for ODEs, Initial value problems and boundary value problems, Fourier series; Fourier convergence theorem, Cosine and Sine series expansion, Approximation; Orthogonal polynomials; the general Sturm-Liouville problems, Jacobi polynomials, trigonometric polynomials, Chebyshev polynomials, Legendre polynomials, derivative of function, differentiation matrices	11
Module-3: Introduction of advanced methods for numerical approximations, Classifications of the methods; Interpolation and non-interpolation-based classifications, Methods for periodic and non-periodic problems and its applications for time dependent problems, stability analysis and error estimates. Scientific computations/coding in MATLAB/python	15
Module-4: Extension of the method from continuous to discontinuous problems. Filtering process for linear and nonlinear problems. Algorithms and implementations of above methods for some standard model problems.	6

Text/Reference books:

1. *L. N Trefethen; Spectral methods in MATLAB, SIAM, Philadelphia-2000*
2. *Hesthaven Jan S., Gottlieb Sigal and Gottlieb David; Spectral Method for Time Dependent Problems, Cambridge University Press-2007*
3. *M K Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computations, New Age Publication-2003*

Subject Code	SM2009	**Course Title**	**Control Systems Engineering**
Contact Hours	L-3, T-0, P-2	**Credit**	4
Programme	B.Tech	**Semester**	IV
Pre-requisites	No	**Mode Core/Elective/EMF**	Core
Evaluation scheme	Quiz#1 :(15%), Mid Term:(25%), End Term:(40%), Lab:(20%),		

VIII. Learning Objective:

IX. Detailed Course Content:

Module1: **Control Systems:** Introduction, System Configurations, Analysis and Design Objectives, Design Process, Modelling of First- and Second-order Mechanical and Electrical Systems **Modelling in Frequency Domain:** Laplace Transform, Transfer Function, Translational and Rotational Mechanical System Transfer Functions, Transfer Functions for Systems with Gears, Electromechanical System Transfer Functions, Electric Circuit Analogues, Nonlinearities, Linearization, Case Studies	**12 H**
Module2: **Modelling in Time Domain:** Introduction, General State-Space Representation and Applications, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function, Linearization, Case Studies **Time Response:** Poles, Zeros, and System Response, First-Order and Second-Order System, Under-damped Second-Order Systems, Case Studies	**10 H**
Module3: **Stability:** Routh-Hurwitz Criterion, Stability in State Space, Case Studies, **Steady-State Errors:** Errors in Unity Feedback Systems, Static Error Constants and System Type, Error Specifications, Error for Disturbances, Case Studies **Root Locus Techniques:** Definition and properties, Sketching and Defining the Root Locus, Transient Response Design via Gain Adjustment, Generalized Root Locus, Root Locus for Positive-Feedback Systems, Pole Sensitivity, Case Studies	**10 H**
Module4: **Frequency Response Techniques:** Bode Plots, Nyquist Criterion, Sketching, Stability, Gain Margin and Phase Margin via the Nyquist Diagram and Bode plots, Obtaining Transfer Functions Experimentally, Case Study **Design via Frequency Response:** Introduction, Transient Response via Gain Adjustment, Lag Compensation, Lead Compensation, Lag-Lead Compensation, PID Controller, Case Studies	**10 H**

Labs	
1. MatLab Fundamentals	**6.** Relay Control System
2. Simulink Fundamentals	**7.** AC servo Control
3. Control Toolbox	**8.** DC servo Control
4. Process Control Simulator	**9.** Frequency Response Analysis
5. Lead/Lag Compensator	**10.** Case study

Text Book: Norman N. Nise, Control Systems Engineering, 6 Ed., Wiley India, 2010

Reference books:

1. K. Ogata, Modern Control Engineering, Prentice Hall India, 2006.
2. B. C. Kuo, Automatic Control Systems, Prentice-hall of India, 7th edition, 2000.

Subject Code	CS8027	**Course Title**	**Distributed Systems**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech & M.Tech	**Semester**	VIII
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz & Assignment: (20%), Mid Term:(30%), Project:(10%), End Term:(40%),		

VIII. Learning Objective:

- **To learn the principles, architectures, algorithms and programming models used in distributed systems.**
- **To examine state-of-the-art distributed systems, such as Google File System.**
- **To design and implement sample distributed system**

IX. Detailed Course Content:

Module1: ***Characterization of Distributed Systems:*** Introduction, Examples of Distributed systems, Resource sharing and web, challenges. ***System Models:*** Introduction, Architectural and Fundamental models. ***Time and Global States:*** Introduction, Clocks, Events and Process states, Synchronizing physical clocks, Logical time and Logical clocks, Global states, Distributed Debugging	10 H
Module2: ***Coordination and Agreement:*** Introduction, Distributed mutual exclusion, Elections, Multicast Communication, Consensus and Related problems. ***Inter Process Communication:*** Introduction, The API for the internet protocols, External Data Representation and Marshalling, Client-Server Communication, Group Communication, Case Study: IPC in UNIX. ***Distributed Objects and Remote Invocation:*** Introduction, Communication between Distributed Objects, Remote Procedure Call, Events and Notifications, Case study-Java RMI.	!0 H
Module3: ***Distributed File Systems:*** Introduction, File service Architecture, Case Study1: Sun Network File System, Case Study 2: The Andrew File System. ***Name Services:*** Introduction, Name Services and the Domain Name System, Directory Services, Case study of the Global Name Service. ***Distributed Shared Memory:*** Introduction Design and Implementation issues, Sequential consistency and Ivy case study, Release consistency and Munin case study, other consistency models.	10 H

Module4: ***Transactions and Concurrency Control:*** Introduction, Transactions, Nested Transactions, Locks, Optimistic concurrency control, Timestamp ordering, Comparison of methods for concurrency control. ***Distributed Transactions:*** Introduction, Flat and Nested Distributed Transactions, Atomic commit protocols, Concurrency control in distributed transactions, Distributed deadlocks, Transaction recovery	10 H

Text/Reference books:

1. Distributed Systems, Concepts and Design, George Coulouris, J Dollimore and Tim Kindberg,Pearson Education, 4th Edition,2009.
2. Distributed Systems, Principles and paradigms, Andrew S.Tanenbaum, Maarten Van Steen, Second Edition, PHI.
3. Distributed Systems, An Algorithm Approach, Sikumar Ghosh, Chapman & Hall/CRC, Taylor & Fransis Group, 2007.

Subject Code	SM2006	**Course Title**	**Kinematics and Dynamics of Machines**
Contact Hours	L-3, T-1, P-2	**Credit**	4
Programme	B.Tech	**Semester**	IV
Pre-requisites		**Mode Core/Elective/EMF**	Core
Evaluation scheme	Quiz & Assignment: (15%), Mid Term:(15%), End Term:(40%), Lab:(15%), Project:(15%),		

VIII. Learning Objective:

To learn fundamental related to mechanism and machines. Synthesis, and analysis of various components of machines including gears, CAM, governors, gyroscope, etc.

At the end of the course the students will be able to understand basic components of the machines, their analysis. Further, they will be trained to geometrically design the components.

IX. Detailed Course Content:

Module1: 1. KINEMATICS : Plain motion, kinematic concepts of links; basic terminology and definitions; inversion of kinematic chains, absolute and relative motion, kinematics and structure diagrams, equivalent linkages, vector diagram, displacement, velocity and acceleration polygons, analysis, instantaneous centres, special graphical methods for slider crank mechanism.	8 H
Module2: 2. KINEMATIC SYNTHESIS OF MECHANISMS : Introduction, Movability of four bar linkage, Function Generation, path generation, motion generation, Errors in synthesis problems, Chebyshev spacing of precision points.	6 H
Module3: 3. GEARS : Fundamental law of gearing, classification and basic terminology, involute tooth profile and its kinematic considerations, type of gears, standards in tooth forms, gear trains, simple, compound, reverted and epicyclic gear trains.	8 H
Module 4 4. CAMS : Classification of Followers and Cams, Terms used in Radial Cams, Cam Mechanism and its Uses, Displacement,Velocity and Acceleration Diagrams, When the Follower Moves With Uniform Velocity, Simple Harmonic Motion, Uniform Acceleration and Retardation and Cycloid Motion, Construction of Cam Profile for a Radial Cam, Operating a Knife Edge, Roller and Flat Faced Follower.	5 H
Module 5 5. GOVERNORS : Functions, Difference between Governor and Flywheel, Various Terms Used, Types of Governor-Watt, Porter,Proell & Hartnell; Inertia Governor, Sensitiveness and	4 H

Stability of Governor; Isochronous Governor, Hunting, Effort and Power ofa Porter Governor, Controlling Force Diagrams For Porter and Spring Controlled Governor, Coefficient of Insensitiveness.	
Module 6 6. TURNING MOMENT AND FLYWHEEL : Turning Moment Diagram for a Four Stroke Cycle I.C. Engine and Multi Cylinder Engine, Fluctuation of Energy and Production of Energy and Co-Efficient of Fluctuation of Energy, Co-Efficient of Fluctuation of Speed, Energy Stored in a Flywheel, Dimensions of the Flywheel Rim, Fly Wheel in Punching Press.	5 H
Module 7: 7. BALANCING OF MACHINERY : Necessity of Balancing, Static and Dynamic Balancing, Balancing of Rotating Masses in one Plane, In Different Planes -Analytical and Graphical Methods, Partial Unbalanced Primary Force in an Engine, Balancing of Reciprocating Masses, Condition of Balance in Multi Cylinder in Line Engines. Balancing of V Engine.	6 H
Module 8: 8. STAIC AND DYNAMIC FORCE ANALYSIS : 2 and 3 force members, torque addition, free body diagram, Inertia forces, Dalembert's Principle, offset inertia forces, equivalent force analysis for various mechanisms, matrix method.	6 H
Lab Experiments: 1. To study inversions of 4-bar mechanisms, single and double slider crank mechanisms. 2. To study various types of gears and gear trains. 3. To study various types of steering mechanisms. 4. Study jump phenomenon in the cam-follower system. 5. Study of Gyroscopic effect and determination of gyroscopic couple on motorized gyroscope. 6. To perform the experiment for static balancing on static balancing machine. 7. To perform the experiment for dynamic balancing on dynamic balancing machine. 8. To understand the balancing of reciprocating masses. 9. Determine the moment of inertia of connecting rod by compound pendulum method and tri-flair suspension pendulum. 10. To verify the relation $T=2\pi\sqrt{lg}$for a simple pendulum. 11. To determine whirling speed of the shaft and study effect of shaft diameter and end conditions on the same. 12. To study the performance characteristics curves, stability, and sensitivity of the Governors: Porter, Proell and Hartnell. 13. To study various types of dynamometers	

Text/Reference books:

1. Norton, Design of Machinery, McGraw Hill Publishing Ltd
2. Rattan S.S., Theory of Machines., Tata McGraw Hill Publishing Ltd.

3. Thomas Bevan, Theory of Machines., CBS Publisher
4. Theory of Mechanisms & Machines by Ghosh & Mallick, EWP
5. John J. Uicker, Jr., Gordon R. Pennock and Joseph E. Sigley (2005), Theory of Machines and Mechanisms (3rdEd), Oxford University Press, Indian Edition.
6. K J Waldron and G L Kinzel (2004), Kinematics, Dynamics and Design of Machinery (2nd Ed), Wiley.

Subject Code	ME5023	**Course Title**	**Materials and Processes in Design**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech	**Semester**	VII
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz I:(10%), Mid Sem:(30%), Quiz II:(10%), End Sem: (50%)		

VIII. Learning Objective: To explore the vast repertoire of materials and manufacturing processes, ranging from traditional "crafts" to the latest technology, to enable their designs to be manufactured effectively and efficiently.

IX. Detailed Course Content:

Module1: Introduction to materials, properties of materials, Ferrous and non-ferrous metals (Fe, SS, Al, Mg, Ni, Ti, Cu), ceramics, wood, structure and properties of wood. Industrial finishes for wood and metals.	10 H
Module2: Plastics: Thermoplastics and Thermosetting plastics, Classification, Composites, and its properties, Influence of materials and processes on product aesthetics. Industrial finishes for plastic.	10 H
Module3: Molding process, fastening and joining, Composites processes, Design in Plastics, Casting.	10 H
Module4: Bending, Drawing process, Forging, Machining.	10 H

Text/Reference books:

1. Thompson R.: Manufacturing processes for design professionals, Thames & Hudson, London 2007
2. Ashby M., Johnson K., Materials and Design: The Art and Science of Material Selection in Product Design: Butterworth-Heinemann, 2002.
3. Degarmo E. P., Materials and Processes in Manufacturing, 9th ed., John Wiley &Sons, 2002
4. Beck R. D.: Plastic Product Design, Van Nostrand Reinhold Co., New York, 1980
5. Garratt J.: Design and Technology, Cambridge University Press, UK, 20004

Subject Code	EMFC03	**Course Title**	**Natural and Artificial Vision**
Contact Hours	L-1, T-0, P-0	**Credit**	1
Programme	B.Tech/B.Des,M.Tech/M.Des	**Semester**	Final UG, PG, PhD
Pre-requisites		**Mode Core/Elective/EMF**	EMF
Evaluation scheme			

VIII. Learning Objective: To learn the approximation of natural vision with the help of different sensors.

IX. Detailed Course Content:

Module1: Intro to bio-inspired imaging: brains, eyes, and computational cameras, Human retinal computation and the on-camera image processing pipeline	2 H
Module2: Low level image processing in the eye and brain, Real vs. artificial neurons	2 H
Module3: Event cameras and neuromorphic chips, Depth from multiple cameras, multiple eyes	2 H
Module4: Depth from defocus, aperture codes and pupil codes , Color dimensionality across species and technologies, Polarization sensing in animals and cameras, Light field cameras and compound eyes	4 H

Text/Reference books:

1. Material provided by Instructor

Subject Code	CS8020	**Course Title**	**Next Generation Networks**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech	**Semester**	VI
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz & Assignments :(20%), Project:(10%), Mid-Sem:(30%), End Sem: (40%)		

IX. Learning Objective:

- **To understand working principles of emerging network technologies, how they are used, what their advantages or disadvantages are, and what their future offers.**
- **To understand the applicable terminology that is critical to a successful learning experience.**
- **To understand the process of evaluating technologies with a view to judging their suitability for specific purposes, and recognizing associated risks.**

X. Detailed Course Content:

Module1: ***Introduction to Next Generation Networks (NGN):*** what is NGN? Evolution trends in ICT network platform towards NGN. Difference between existing telecommunication environment and next generation converged environment. ***Factors motivating NGN:*** economic, technological and social. Building blocks for NGN. NGN services, challenges, opportunities. ***Convergence:*** what is convergence and why is it possible now? Network convergence, service convergence, device convergence, convergence in content. From technology push to service pull. ***NGN applications:*** Internet connectivity, ecommerce, call center, third party application service provision, integrated billing, security and directory enable networks.	10 H
Module2: ***NGN:*** numbering, naming and addressing. ***Conceptual model for NGN:*** access layer, transport layer, control layer, service layer. ***NGN architecture:*** softswitch based, IMS based and TISPAN. ***IMS architecture:*** nodes, S-CSCF, P-CSCF, I- CSCF, application servers, BGCF, PSTN/CS gateway, media resource functions. IMS advantages, ***NGN protocol stack:*** fundamental protocols: SIP, SDP, AAA, RTP, RTCP, Megaco/H.248.	10 H
Module3: ***Supporting protocols:*** XCAP, SOAP. Fixed mobile convergence (FMC). Convergence using IMS- a case study. IMS based NGN IPTV architecture. ***Next generation access network:*** **wireline**: fiber to the premises (FTTP), long-haul managed	10 H

Ethernet. **Broadband wireless access**: Local area network (Wi-Fi), Wide area network (WiMAX), satellite networks, and mobile networks: 3G, 4G, LTE, and 5G. ***Next generation core network:*** role of core network, enabling control and reconfigurability. VoIP: principles, how telephony is provided over IP network, various VoIP scenarios.	
Module4: NGN management and provisioning- configuration, accounting, performance and security. Future enhancements- adaptive self-healing networks. ***Software defined networking (SDN):*** basic concepts, SDN software stack. Applications: network virtualization, data-center traffic management, wide area traffic management. SDN systems challenges: scalability, security, fault tolerance. Future of SDN.	10 H
Text/Reference books: 1. Next generation Telecommunication Networks, Services and Management by Thomas Plevyak, Veli Sahin Wiley & IEEE Press Publications 2012 2. Next Generation Network Services, Neill Wilkinson, John Wiley Publications 2002 3. Next Generation Networks Monique J. Morrow CISCO Press 2007 4. Next Generation Networks: Perspectives and Potentials 156Jingming Li Salina, Pascal Salina John Wiley Publications 2008	

Subject Code	SM3011	**Course Title**	**Industrial Automation**
Contact Hours	L-3, T-0, P-2	**Credit**	4
Programme	B.Tech/B.Des M.Tech/M.Des B.Tech (SM)	**Semester**	V
Pre-requisites		**Mode Core/Elective/EMF**	Core
Evaluation scheme	Quiz: 2 :(20%), Mid-Sem:(20%), End Sem: (30%), Project/Lab: (30%),		

9. Learning Objective:
1. To understand the construction, operation and installation of various PLCs.
2. To provide the knowledge on interfacing the PLCs and field devices with communication protocols.
3. To understand the concepts of DCS and SCADA systems.

10. Detailed Course Content:

Module1: Basics of industrial controllers, different modules, programming of controllers. NO/NC concept, Various Timer instructions – On delay, Off delay, Cyclic and Retentive timers, Up /Down Counters, control instructions.	12H
Module2: Applications of PLC Motor start and stop, Simple materials handling applications, Automatic water level controller, conveyor systems, Automatic lubrication of supplier Conveyor belt, Automatic car washing machine, Bottle label detection and process control application.	14H
Module 3: Memory mapping (I/O addressing), communication with peripherals, upload / download, monitoring processes, Digital and analog addressing, Analog scaling, Advanced level programming with instructions.	8H
Module 4: Converters: Scada System and Architecture Engineering station design, Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries – SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA/HMI Systems Various SCADA architectures, Configuring alarms.	8H
Text/Reference books:	

1. John Webb, Programmable Logic Controllers: Principles and Applications,5th edition Prentice Hall of India, 2012.
2. Gary Dunning, Introduction to Programmable Logic Controllers,3rd India edition, Cengage Learning, 2007
3. Krishna Kant Computer Based Process Control, Prentice Hall of India, 2004.

Subject Code	OE2M09	**Course Title**	**Approaches to Machine Learning**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech	**Semester**	I
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz I & Quiz II:(15% each), Mid-Sem:(30%), End Sem: (40%),		

VIII. Learning Objective: This course provides a comprehensive introduction to probabilistic approaches in machine learning, emphasizing foundational principles and practical applications. Students will explore how uncertainty is modeled and managed in machine learning tasks, gaining hands-on experience in implementing probabilistic models using Python programming. The course aims to equip students with the essential skills to understand, apply, and critically evaluate probabilistic methods in various machine learning contexts.

Prerequisites:
- Basic understanding of calculus and linear algebra.
- Familiarity with programming concepts (Python preferred).

IX. Detailed Course Content:

Module 1: Introduction to Probability and Uncertainty - Basic probability concepts: events, sample spaces, probability axioms. - Random variables, probability distributions (discrete and continuous). - Properties of probability distributions: mean, variance, covariance. - Introduction to uncertainty in machine learning and its significance.	10 H
Module 2: Bayesian Inference - Bayes' theorem and its application in machine learning. - Prior, likelihood, and posterior distributions. - Maximum a posteriori (MAP) estimation and Bayesian parameter estimation. - Bayesian model selection and model averaging. - Regularization techniques in a Bayesian framework.	10 H
Module 3: Probabilistic Graphical Models (PGMs) - Introduction to graphical models and their representation. - Bayesian networks: Directed graphical models, conditional independence, parameter estimation. - Markov networks: Undirected graphical models, factorization, inference algorithms (e.g., belief propagation, Gibbs sampling). - Learning structure and parameters of PGMs. - Applications of PGMs in classification, regression, and clustering.	10 H
Module 4: Gaussian Processes - Introduction to Gaussian processes and their properties. - Gaussian process regression: Kernel functions, hyperparameter optimization, prediction intervals. - Gaussian process classification. - Applications of Gaussian processes in machine learning, including Bayesian optimization and time series prediction.	10 H
Project: A final project where students design and implement a probabilistic model for a given problem, demonstrating proficiency in applying probabilistic approaches to real-world tasks.	02 H
Text book:	

"Pattern Recognition and Machine Learning" by Christopher M. Bishop

Reference books/Additional Resources:

1. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
2. Lecture slides and supplementary materials provided by the instructor.
3. Online tutorials, research papers, and documentation for Python programming and relevant machine learning libraries (e.g., NumPy, TensorFlow, PyMC3).

Subject Code	ME8023	**Course Title**	**Computer Aided Manufacturing**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech/B.Des, M.Tech/M.Des, PhD	**Semester**	VI
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz :(20%), Mid-Sem:(30%), Assignment:(10%), End Sem: (40%),		

VIII. Learning Objective: To analyze different aspects of CAM, CNC programs, basics robotics, material handling system, production management system and thus, create interdisciplinary thoughts

IX. Detailed Course Content:

Module1: ***Computer aided manufacturing*** **(08 Hours)** CAM concepts, objective sense scope, nature and type of manufacturing system, evolution, benefits of CAM, role of management in CAM, concepts of computer integrated manufacturing , impact of CIM on personal, role of manufacturing engineers, CIM basic functions	08 H
Module 2: **NC/CNC machine tools (08 Hours)** Introduction, Numerical Control – its growth and development, Components of NC system, Input devices, Control systems – point to point, straight cut, and continuous path NC, Open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, Applications of NC systems, Merits and demerits Concepts of Computer Numerical Control (CNC), Machining Center, and Direct Numerical Control (DNC), and their advantages	08 H
Module3: **Material Handling and Storage (08 Hours)** Overview of Material Handling Equipment, Automated material handling equipment – AGVs, Conveyor systems, Performance analysis of material handling systems, Automated material storage systems – ASRS and Carousel storage, Analysis of automated storage systems.	08 H
Module 4: **Flexible manufacturing system and Manufacturing Support Functions (08 Hours)** Types of flexibility, FMS components, FMS application and benefits, FMS planning and control Manufacturing Support Functions: Introduction to Group Technology (GT), Computer Aided Process Planning (CAPP), Material Requirement Planning MRP (MRP), Capacity Planning, Scheduling etc.	08 H
Unit 5: ***Industrial robotics and Additive Manufacturing (AM)*** **(08 Hours)** Robot anatomy and related attributes: classification of robots, robot control systems, end effectors, sensors, accuracy and repeatability, Industrial robot application, robot part programming, simple problems Reverse engineering, Different AM processes and relevant process physics, AM process chain, Application level: Direct processes – Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing	08 H

Text/Reference books:

1. Ibrahim Zeid: Mastering CAD CAM, TMH
2. Mikell P Groover, Automation, production systems and computer integrated manufacturing, Prentice

Hall of India
3. Radhakrishnan P, Subramanyan S and Raju V., CAD/CAM/CIM, 2nd Edition, New age international limited, New Delhi
4. Manu Srivastava, Sandeep Rathee, Sachin Maheshwari, TK Kundra "Additive Manufacturing: Fundamentals and Advancements", CRC Press, Taylor and Francis, Boca Raton: CRC Press, Taylor & Francis group
5.Introduction to Robotics by Saeed B. Niku, Wiley

Subject Code	OE2M06	**Course Title**	**Fundamental of Robotics**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	B.Tech	**Semester**	IV
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz/Assignment :(15%), Mid-Sem:(15%), End Sem: (40%), Lab:(15%), Project : (15%)		

VIII. Learning Objective:

The course is designed to provide fundamental concepts related to Robotics. The students will be introduced with the robots, kinematic analysis of the manipulator,

IX. Detailed Course Content:

Module 1: Introduction [2 H] i. Introduction and Classification of robots ii. Introduction to Mechanical, Electrical and Electronics Elements of robots such as joints, links Module 2: Robot Kinematics [10 H] iii. Robot as Mechanism iv. Joints and degrees of freedom v. Position and orientation of a rigid body vi. Homogeneous transformations, Euler Angle vii. Direct kinematics of serial robots, Introduction to D-H parameters and its physical significance viii. Inverse kinematics of serial robots ix. Kinematics of mobile robot, non-holonomic and holonomic robots Module 3: Sensors and Actuators [5 H] x. Sensors for robots: Introduction and their characteristics: a. Position, Velocity and Acceleration sensors b. Force, pressure and Torque sensors c. Light, infrared, proximity and range finder sensors xi. Actuators for robots: Introduction to servo and stepper motors, pneumatic and hydraulic actuators Module	28 H

4: Robot Motion and Control [8 H]

xii. Brief introduction to trajectory planning for serial robots

xiii. Reactive navigation for mobile robot

xiv. Global navigation

xv. Trajectory-following control – basics of feedback and motion control

Module 5: Intelligent robots [3 H]

xvi. Intelligent robots: Programmable and autonomous

Lab:

1. Demonstration of components of a robot
2. Practice on joints, links and degrees of freedom
3. Simulation of position and orientation of a robot
4. Simulation for forward kinematics of puma or similar robot
5. Simulation for kinematics of mobile robot
6. Inverse kinematics analysis of puma or similar robot
7. Practice on Sensors and actuators (2 labs)
8. Simulation and hardware implementation of Trajectory following robot (4 labs)

Text/Reference books:

1. Introduction to Robotics by S.K. Saha
2. Introduction to Robotics by Saeed B. Niku
3. Robot Motion and Planning by Choset
4. Introduction to Robotics: Mechanics and Control by Craig
5. Robot Modeling and Control by M. Spong, S. Hutchinson, and M. Vidyasagar.

Subject Code	CS8028	**Course Title**	**Hardware Security**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech, M.Tech, PhD	**Semester**	Odd/Even
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz: (10%), Assignment:(10%), Mid-Sem:(20%), Project:(20%),End Sem: (40%)		

VIII. Learning Objective: The main goals for this course are: (1) Learning the state-of-the-art security methods and devices; (2) Integration of security as a design metric, not as an afterthought; (3) Protection of the design intellectual property against piracy and tampering; (4) Better understanding of attacks and providing countermeasures against them; (5) Detection and isolation of hardware Trojans; and (6) Counterfeit Electronics: Detection and Prevention.

IX. Detailed Course Content:

Module1: Digital System Design: Basics and Vulnerabilities Introduction, Digital System Specification, Digital System Implementation, Function Simplification and Don't Care Conditions, Sequential System Specification, Sequential System Implementation, Vulnerabilities in Digital Logic Design. Basics of VLSI Testing and Testability.	08 H
Module2: Different Types of Attacks and Modular Exponentiation Physical Attacks (PA) Basics, Physical Attacks/Supply Chain attacks (Hardware Trojan, Side channel, IP Piracy, Overbuilding, Reverse Engineering, and Counterfeiting), Countermeasures for different attacks. Building Secure Systems, Modular Exponentiation (ME) Basics, ME in Cryptography, ME Implementation and Vulnerability, Montgomery Reduction.	08 H
Module3: Intellectual Property Protection Introduction to IP Protection, Watermarking Basics, Watermarking Examples, Good Watermarks, Fingerprinting, Metering, Hardware Metering, Logic Obfuscation/Locking.	10 H
Module4: Hardware Trojan and its Countermeasures Hardware Trojan Taxonomy, Hardware Trojan Detection Approaches: Destructive and Non-Destructive, Case Studies on Hardware Trojan Detection approaches. Design of Security and Online Monitoring Approaches for Hardware Trojan Protection.	10 H
Module5: Side Channel and Counterfeiting Attacks and their Countermeasures Side channel attacks (SCA) attacks include cache attacks, power analysis, timing attacks, and scan chain attacks. Countermeasures from software, hardware, and algorithm design. Counterfeiting, Countermeasures to counterfeiting.	06 H

Text/Reference books:

1. Tehranipoor, Mohammad, and Cliff Wang, eds. *Introduction to hardware security and trust*. Springer Science & Business Media, 2012. DOI 10.1007/978-1-4419-8080-9.
2. Mukhopadhyay, Debdeep, and Rajat Subhra Chakraborty. *Hardware security: design, threats, and safeguards*. CRC Press, Taylor & Francis Group, 2015.

Subject Code	ME5005	Course Title	Near Net Shape Manufacturing
Contact Hours	L-3, T-0, P-0	Credit	3
Programme	M.Tech	Semester	III
Pre-requisites		Mode Core/Elective/EMF	Elective
Evaluation scheme	Quiz I (10%), Mid Term:(30%), Quiz II (10%), End Term: (50%),		

VIII. Learning Objective:

The objective of the course is to introduce the fundamental knowledge on the processes used for manufacturing near net shapes. This also introduces the applications of such processes

IX. Detailed Course Content:

Module1: Concept of Shape, size, accuracy, tolerances and surface roughness. Economic and technological factors, improved material and energy efficiency, dimensional accuracy, product integrity and reduced manufacturing cost through near net processing. Introduction and fundamentals of Casting of complicated shapes: automotive components, casting of light alloys – Aluminum, Magnesium and Titanium alloys	10 H
Module2: Injection moulding: Thermoplastics, thermoset plastics and composites processing methodologies.	10 H
Module3: Plastic deformation processes; Warm forging, Flashless forging, Cold forging. Super plastic forming, Liquid forging, Rheo-forging and Isothermal forging processes.	10 H
Module4: Advances in near net shape manufacturing: Metal injection moulding, Laser engineered net shaping, Powder metallurgy and field assisted sintering technologies	10 H

Text/Reference books:

1. **DeGarmo's Materials and Processes in Manufacturing 13e,** J. T. Black, Ronald A. Kohser, Wiley, 2019.
2. **Manufacturing Processes for Engineering Materials 6e,** Serope Kalpakjian, Steven Schmid, Pearson, 2017.
3. **Near Net Shape Manufacturing Processes,** Editor Kapil Gupta, Springer, 2019.

Subject Code	OE3M33	**Course Title**	**Electrical Drives and Devices**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	B.Tech/B.Des, M.Tech/M.Des, B.Tech	**Semester**	III
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz: 2 (20 Marks), Mid Term:(20%), End Term: (30%) , Project/Lab: (30%),		

- Learning Objective:
    1. Conceptualize basic drive system and analyze it for different load systems.
    2. Selection of motor power and torque rating for a particular application.
    3. Develop control circuitry and devices for control of motors.
- Detailed Course Content:

Module1: Basics of electrical drives, Components of ED, Source, power modulator, machines and load, Dynamics of ED, 4 quardrant operation, Operations details through some examples.	8H
Module2:Various types of electric motors, D C Motors of kind, A.C. Motors of kind, converters, Static Control of Motors:Contactors and relays for electric drives, Control circuits for automatic starters of DC and AC motors. Speed control of motors.	6H
Module3:Converters: DC-DC converter (choppers), AC-DC types, AC-AC, regulators Inverters: DC-AC converters, Voltage source (VSI) and current source type (CSI).	8H
Module4:Power supplies, AC, DC, Estimation of Motors Rating: Thermal modeling of motors, Types of duty cycles, Calculation of motor rating for duty cycles, Overload factor calculation for short and intermittent duty cycle, Use of load diagrams. Motor selection guide.	6H

Text/Reference books:

1.Dubey, G.K., Fundamentals of Electric Drives, Narosa Publications (2001).
2. Pillai, S.K., a Course in Electric Drives, New Age International (P) Limited, Publishers (1989).

Subject Code	OE4M72	**Course Title**	**Introduction to Computational Materials Science**
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B.Tech / M.Tech	**Semester**	VII
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz 1: (10 %), Mid Term:(30%), Quiz 2: (10 %), End Term: (50%) ,		

VIII. Learning Objective: Computational materials modeling is an increasingly important branch of materials science due to the evolution of modeling frameworks, invention of novel numerical algorithms and increased computer capability. As a consequence, modeling and simulation are emerging as powerful complementary approaches to experiment and traditional theory.

IX. Detailed Course Content:

Unit	Content	No of Lectures
1	Basic concept of CMS	2
	Basic concept of Crystal structure, defects (slip and twin), miller indices, and mechanical behaviour of materials	4
	Applications of Pure metal, alloys, composite, and functionally graded materials	2
2	Nano and Microscale simulation algorithms Monte Carlo, Molecular Dynamics, Ab-initio, and Density Function Theory	8
3	Meso and Macroscale simulation algorithms Dislocation Dynamics, FEM, and Cellular Automata	6
4	Crystal plasticity (CP) Introduction, need of CP, mathematics of CP, Applications, Material characterisation technique, Open-source software (DREAM.3D and PRISMS-Plasticity)	6
	Introduction to Phase field simulation	2
	Introduction to Fatigue and fracture simulation	2
5	Open-source software for CMS • Damask, Neper, Lammps, Calphad, and some python libraries	5
6	DREAM.3D and PRISMS-Plasticity simulation practical	5

Refence/Text Books

1. Franz Roters and Dierk Raabe: Crystal Plasticity Finite Element Methods in Materials Science and Engineering, Wiley- VCH Verlag, 2010.
2. K. Ohno, K. Esfarjani, and Y. Kawazoe: Computational Materials Science - From Ab Initio to Monte Carlo Methods, Springer, 1999.
3. Wolfram Hergert, Arthur Ernst, Markus Dane: Computational Materials Science - From Basic Principles to Materials Properties, Springer, 2004.

Subject Code	OE4M74	**Course Title**	**AI and ML for Engineering Applications**
Contact Hours	L-2, T-0, P-2	**Credit**	3
Programme	**Ph.D. ;Open for M.Tech. and Final Year B.Tech.**	**Semester**	I
Pre-requisites		**Mode Core/Elective/EMF**	Elective
Evaluation scheme	Quiz/Assignment (15%), Mid-Term (15%), End-Term (40%), Lab (15%), Course Project (15%)		

I. Learning Objective:

- To acquaint the students with the basic concept of AI and ML
- Practicing AI and ML tool using Python programming.
- To acquaint students with the application of AI and ML in various problems of Engineering.

Detailed Course Content:

Module 1: ***Introduction to AI and ML*** Introduction to Artificial Intelligence (AI) andMachine Learning (ML), Need of AI and ML in Mechanical Engineering. Data Understanding, Data Preprocessing, Data Engineering. Data Representation, and Visualization.	02 H
Module 2: ***Introduction to AI Approaches*** Basics of AI - Search algorithms, heuristic search and graph based search algorithms. Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical.	02 H
Module 3: ***Introduction to Approaches to ML*** Machine learning – basic concepts. Supervised learning, Unsupervised learning, Reinforcement learning	02 H
Module 4: ***Feature Extraction and Selection*** **Feature extraction:** Statistical features, Principal Component Analysis. **Feature selection:** Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering	05 H
Module 5: ***Classification and Regression*** **Classification**: Decision tree, Random forest, Naive Bayes, Support vector machine. Neural networks **Regression**: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). **Clustering algorithms (unsupervised learning)** K means, Agglomerative Hierarchical Clustering. Applications of classification, regression and clustering algorithms in Mechanical Engineering	05 H
Module 6: ***Development of ML Model*** Classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.),	04 H

Hyper parameter Tuning, Predictions.	
Module 7: ***Introduction to Deep Learning*** Deep learning – why deep learning, deep neural networks. Training a deep learning network. Standard deep learning architectures – AlexNet, VGG, Inception and ResNet models.	03 H
Module 8: ***Application of AI and ML for Engineering Applications*** Application examples for implementing AI and ML in Engineering such as Fault Diagnosis of Rolling Element Bearing, Chatter Detection in Machine Tools, Biomedical Applications, EEG and EMG signal classification, Crop disease identification.	05 H
Lab Experiments: 1. Introduction to Python Programming 2. Data Processing, Data representation and visualization 3. To extract features from given data set and establish training data. 4. To select relevant features using suitable technique. 5. To use PCA for dimensionality reduction. 6. To classify features/To develop classification model and evaluate its performance 7. To develop regression model and evaluate its performance (any one algorithm). 8. Markov process for modelling manufacturing processes. 9. Reinforced Learning for optimizing engineering designs 10. Application example 1 11. Application example 2	

Text and Reference Books:

1.	Steven W. Knox, “Machine Learning: a Concise Introduction”, Wiley, 2018
2	Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
3.	B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
4.	Stuart Russell and Peter Norvig (1995), “Artificial Intelligence: A Modern Approach,” Third edition, Pearson, 2003.
5.	Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH
6.	Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
7.	Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
8.	Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)

Subject Code	OE3C40	**Course Title**	Tiny ML
Contact Hours	L-3, T-0, P-0	**Credit**	3
Programme	B. Tech.	**Semester**	VII
Pre-requisites	Python Programming, Basics of C and C++	**Mode Core/Elective/EMF**	Open Elective
Evaluation scheme	Quiz/ Assignment/ Project/ End Sem		

Detailed Course Content

IX. Learning Objective:

1. To learn about model development, compression techniques, efficient memory and CPU management
2. TinyML course covers topics in the domain of machine learning on edge devices.
3. To learn about how to develop classical and deep learning approaches to be deployed on small microcontrollers.

X. Detailed Course Content:

Module1: TinyML Landscape, Applications, and Challenges, TinyML Lifecycle and Workflow, Model Compression Techniques, Recap on Necessary ML Background: ML Algorithms, Neural Networks, Introduction to Hardware and Software Used in the Course.	14 H
Module2: Pruning ML models, Quantization Aware Training (QAT) and Post Training Quantization (PTQ), Knowledge Distillation, Tiny Deep Learning, TensorFlow Lite (TFLite) for TinyML	14 H
Module3: End to End Development, Sparsification, Size vs Speed vs Accuracy, Optimizers Develop a gesture sensor – Nano, Develop a object detector Portenta, Develop a wake word detector – Nano, TinyML for Visual Wake Words, TinyML for Anomaly Detection, Wizard Magic Wand, TinyML for Predictive Maintenance, TinyML for American Sign Language (ASL) Interpretation, TinyML for American Sign Language (ASL) Interpretation	14 H