Course Content of
Engineering Sciences

AcSIR – Engineering Sciences coursework

1. **Common courses**
2. **Lab-wise courses**
    a. **CSIR-CBRI**
    b. **CSIR-CEERI**
    c. **CSIR-CMMACS**
    d. **CSIR-CSIO**
    e. **CSIR-CIMFR**
    f. **CSIR-IICT**
    g. **CSIR-IIP**
    h. **CSIR-IMMT**
    i. **CSIR-NCL**
    j. **CSIR-SERC Campus**

AcSIR- Engineering Sciences Common courses

ENG ( ) 1-002 : 3-0-0-3: Mathematics for Engineers

Linear Algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimensions, Gram-Schmidt method for orthogonal basis set, Orthogonal projections. Matrices and Linear Mappings, Solution methods for Linear Simultaneous Equations, Eigenvalue problems.

Vector Analysis : Vector differentiation and its applications, Vector operators: Grad, Div and Curl. Vector integration & related Integral Theorems (Gauss' Divergence and Stoke's Theorems) and applications. Cylindrical and Spherical Co-ordinate Systems.

Differential Equations: Linear ODEs of first and second orders, Systems of first order ODEs, Applications of homogeneous and non-homogeneous linear second order equations. Partial Differential Equations, Solving various ODEs, PDEs, Fourier Series and Applications, The Laplace Transform.

ENG ( ) 1-003 : 2-0-2-3: Numerical Methods in Engineering

Introduction, finite floating point arithmetic, catastrophic cancellation, chopping and rounding errors; Solution of nonlinear equations; bisection method, secant method, Newton's method, fixed point iteration, Muller's method;

Numerical optimization; Method of golden section search, Newton's method optimization; Solutions of linear algebraic equations; forwarding Gaussian elimination, pivoting, scaling, back substitution, LU-decomposition, norms and errors, condition numbers, iterations, Newton's method for systems, computer implementation; Interpolation; Lagrange interpolation, Newton interpolation, inverse interpolation;

Numerical Integration; finite differences, Newton cotes rules, trapezoidal rule, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ordinary differential equations; Euler's method, Runge-Kutta method, multi-step methods, predictor-corrector methods, rates of convergence, global errors, algebraic and shooting methods, for boundary value problems, computer implementation

ENG ( ) 1-004 : 2-0-2-3: Statistical methods for engineers

Statistical Computing: Graphical representation of statistical data, Frequency distribution, Measures of central tendency and dispersion, Random variable and it's expectation and variance, Probability models – Binomial, Poission and normal.

Bivariate Frequency Distributions. Scatter Diagram, Product Moment, Correlation coefficient and its properties (statements only), regression lines, correlation index and correlation ratio, Spearman rank correlation. Multiple linear regression, multiple correlation, partial correlation (without derivation). Random sampling (with replacement and without replacement), expectations and standard error of sampling mean (without derivation), expectation and standard error of sampling proportions.

Point of estimation of parameters, Maximum likelihood estimation, interval estimate of parameters, test of significance based on t, F and CHI square distribution.

Large sample tests, Tests based on Pearsonian frequency CHI-square.

ENG ( ) 1-005 : -0-2-4: Transport phenomena

Linear algebra and calculus relevant to transport phenomena

Conservation equations

Examples in transport phenomena

ENG ( ) 1-006 : 2-0-2-3: Thermodynamics and Statistical Mechanics

Classical Thermodynamics, ideal gases

Solution thermodynamics

Equilibrium thermodynamics

Non-equilibrium thermodynamics

Ensemble methods

ENG ( ) 1-007 : 2-0-2-3: Reaction and Reactor Engineering

Chemical kinetics

Homogeneous reactor analysis and design

Heterogeneous reactor analysis and design

Special reactors

ENG ( ) 2-001 : 3-0-2-4: Optimization Techniques in Engineering

Classical optimization methods, unconstrained minimization; Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, Feasible direction and projections. Integer and Geometric programming, multi-objective optimization, genetic algorithms (GAs), multi-objective GA, simulated annealing techniques, engineering applications.

ENG ( ) 2-002 : 3-0-2-4: Soft Computing

Artificial neural network (ANN), Supervised and unsupervised learning of ANN, fuzzy logic, fuzzy membership function distributions, fuzzy logic rules, fuzzy and neuro-fuzzy inference systems, Genetic-fuzzy system, rough sets, The Hopfield Network; Support Vector Machines: Support vector machines and other kernel based learning algorithms, Implementation techniques for SVM, application of SVM for engineering problems; Evolutionary algorithms, hybrid-system.

ENG ( ) 2-003 : 3-0-2-4: Finite Element Methods

Review of matrix methods of structural analysis ; Stationary Principles, Rayleigh-Ritz method and Interpolation : Principle of stationary potential energy, Rayleigh-Ritz method, Stationary principles and governing equations, Finite element form Rayleigh-Ritz method, Method of Weighted Residuals. The Galerkin Method and the Weak Forms for various elastic systems. FEM formulation from a functional, Interpolation, C0 and C1 elements; Displacement based Element formulations: Overview of element stiffness matrix, Load formulations, Equilibrium and compatibility, convergence requirements, patch test, stress calculations, plane stress, plane strain, axisymmetric and solid finite elements, triangular, quadrilateral, tetrahedral and hexahedral elements. Isoparametric finite elements :1-D, 2-D and 3-D shape functions, Lagrangian and Serendipity family of elements, numerical integration, validity of isoparametric elements, element and mesh instabilities, coordinate transformations, handling of constraints; Plate bending elements :Plate bending theory, Mindlin and Kirchhoff element formulations, Concepts of locking, Full, reduced integration and selective reduced techniques,

ENG ( ) 2-004 : 3-0-2-4: Finite Element Method for Fluid Dynamics

Fundamental concepts; strong form, weak form, Galerkin approximation; matrix equations, element and global point of view; numerical integration – Guassian

quadrature; temporal discretization - generalized trapezoidal rule; compressible and incompressible flows; implementation of the methods; issues related to high performance computing.

ENG ( ) 2-005 : 3-0-2-4: Computational Fluid Flow & Heat Transfer

Discretisation procedure in Finite-difference and Finite-volume. Navier-Stokes, Energy equations. Staggered rectilinear grids. Explicit methods : MAC, SMAC. Implicit Methods, SIMPLE and SIMPLER. Matrix methods, conjugate gradient method, strongly Implicit Procedure. Grid-Generation:Algebraic, Transfinite, Poisson equation methods. Finite-difference Navier-Stokes solution on nonorthogonal grids, transformation. Collocated grids. Finite-volume methods on non-orthogonal grids. Turbulence modelling, k-e modeling.

ENG ( ) 2-006 : 2-1-0-3: Digital Signal Processing & Applications

Introduction: Elements of a Digital Processing system, advantage of digital processing over analog processing, continuous time signals, discrete time signals, sampling of analog signals, sampling theorem.

Discrete time signals and systems: Classification, block diagram representation, analysis of linear systems, response of LTI systems to arbitrary inputs, convolution, causal systems, stability, finite duration and infinite duration impulse response, recursive and non-recursive systems, description by difference equations.

Z transform: Direct and inverse Z transform, properties, poles and zeros, techniques of finding inverse Z- transform, analysis of LTI systems in z-domain. Frequency Analysis: Fourier series of continuous and discrete-time signals, power density spectrum, Fourier transform, cestrum, frequency-domain characteristics of LTI systems, LTI systems as filters.

Discrete Fourier Transform: Frequency domain sampling properties of DFT, Linear filtering methods based on the DFT, frequency analysis of signals using DFT, FFT algorithms. Design of digital filter: Characteristics & design of filters.DSP Hardware: Introduction to DSP processors, their architecture

ENG ( ) 2-007 : 2-0-2-3: Advanced concrete technology

Cement: Composition of opc-manufacture-modified portland cements-hydration process of portland cements-structure of hydrated cement pastes

Admixtures: Composition of opc-manufacture-modified portland cements-hydration process of portland cements-structure of hydrated cement pastes

Aggregates: Mineral admixtures-slags-pozolanas and fillers-chemical admixtures-solutes retarders-air entraining agents- water proofing compounds-plasticizers and super plasticizers

Fresh concrete: Shape and mechanical properties-absorption and physical durability-chemical stability and packing characteristics

Properties of concrete: Workability-mix proportioning-mixes incorporating fly -ash -mixes for high performance concrete Interfacial transition zone-fracture strength-mechanical properties-high strength concrete-shrinkage-creep- other properties

Durability of concrete: Basic consideration-Stability of constituents-Chemical Attack-Corrosion of Reinforcing steel

Special Concrete - High performance concrete, High volume fly ash concrete, Fibre reinforced concrete, Self compacting concrete, Ready mixed concrete, Geo-polymer concrete, Polymer modified concrete, Recycled aggregate concrete etc.

ENG ( ) 2-007 : 2-0-2-3: Dynamics of Structures

Introduction: dynamic vs. static response; types of dynamic loading: seismic, impact, wind, blast; Principles of dynamics - Formulation of equations of motion by different methods - single degree of freedom systems - free and forced response - effect of damping; Multi-degree of freedom systems -Formulation of equations of motion - Eigen values problems - Modes shapes and orthonormality of modes -Approximate methods of extraction of eigen values and natural frequency; Seismic response spectra Response spectra parameters; response spectra relationships; Dynamic response of MDOF systems - Mode superposition techniques -Numerical integration procedures; Continuous systems - Modeling - free and forced vibration of bars and beams; MDOFs : Response spectra analysis; SRSS and CQC combination methods; Introduction to frequency domain analysis; Time domain vs. frequency domain; Fourier series; the Fast Fourier transform (FFT);assessing frequency content; frequency based filtering; Application of finite element method in structural dynamics, wave propagation problems, introduction to random vibrations

CSIR-CBRI

ENG(CBRI) 1-137	Numerical Methods	L-T-P-C 3-0-0-3
Objective	To acquaint the students with different numerical tools that are required to solve engineering problems	
Modules	Interpolation, Errors in interpolation. Matrices: Numerical solution of ordinary differential equations, Numerical solution of Partial Differential Equations, Special fuctions: Introduction to Finite Element Method (FEM) and its applications Introduction to fuzzy logic, Artificial Neural Network Introduction to the softwares like MX-EXCELL, SPSS and MATLAB	

ENG(CBRI) 1-139	Advanced Geotechnical and Foundation Engineering	L-T-P-C 3-0-0-3
Objective	To impart the necessary knowledge on geotechnical engineering required for building engineering and disaster mitigation with respect to geohazard.	
Modules	Introduction to Geotechnical engineering Deep foundation Ground Improvement Techniques Stability of Slope Reinforced Soil Environmental Geotechnics	

ENG(CBRI) 1-141	Engineering Materials for Infrastructure	L-T-P-C 3-0-0-3
Objective	To study about building materials required for construction and maintenance of building infrastructure	
Modules	Conventional building materials Non-conventional building materials Advanced building materials Methods of characterization of building materials Types of cements, Chemical admixtures	

ENG(CBRI) 1-143	Analysis of Building Structure	L-T-P-C 3-0-0-3
objective	To impart knowledge about advanced analysis methodologies that are required for efficient design of buildings	
Modules	Static analysis – stiffness and flexibility methods Application problems using finite element technique, Introduction to non-linear analysis. Dynamic analysis Single degree of freedom system Multiple degree of freedom systems, Introduction to computer programs for dynamic analysis	

ENG(CBRI) 1-145	Research Methodology for Engineers	L-T-P-C 2-0-0-1
Objective	To make the student aware on the ethics necessary to be followed in research and the methodologies generally adopted for carrying out data analysis and handling of primary and secondary data	
Modules	Introduction to Research Methodology Designing and implementing a research project, Measurements in research, Communicating research results, Case studies Primary and secondary data, Analysis of data Quantitative analysis Professional ethics, Ethics in Research, Plagiarism, Communication Skills	

ENG(CBRI) 1-147	Laboratory - I Geotechnical Engineering, Materials and Environmental science and Technology	L-T-P-C 0-0-4-2
Objective	To carry out laboratory experiments to evaluate the Geotechnical, physical and chemical properties of the material and to do the necessary characterisation	
Modules	**Geotechnical Laboratory Work** Laboratory Soil Investigation Field Soil Investigation **Materials and Environmental Science and Technology Laboratory Work** Physical and Chemical testing of cement and other building material Instrumental methods for analysis of building materials	

ENG(CBRI) 1-136	Design of Building Structures	L-T-P-C 3-0-0-3
Objective	To impart knowledge about the advanced design methodologies considering different environmental loading.	
Modules	Design loads with special reference to earthquake and wind loads. Wind effects on buildings Concept of earthquake resistant design of buildings Introduction to plastic analysis in steel structures Computer applications in the design.	

ENG(CBRI) 1-138	Disaster Resistant Building System - I	L-T-P-C 3-0-0-3
Objetive	To educate about the earthquake resistant foundation system and Fire safety system in buildings	
Modules	**Earthquake Resistant System** Introduction to geotechnical earthquake engineering and seismic properties of soil Seismic bearing capacity of shallow foundations Seismic analysis of pile foundation Introduction to earthquake resistant building system **Fire safety system in buildings** Fundamentals of fire Growth and spread of fire Reaction to fire characteristics and fire retardant materials and techniques Smoke movement and control Fire dynamics and modelling Fire detection and Fire extinguishment.	

ENG(CBRI) 1-140	Concrete Technology	L-T-P-C 3-0-0-3
Objective	To make the students aware about the advancements that are taking place in the area of concrete technology	
Modules	Advances in Concrete Durability of concrete Special Concrete Concrete Technology - Sustainable & durable construction with concrete Quality Control	

ENG(CBRI) 1-142	Planning, Regulations & Management of Buildings	L-T-P-C 3-0-0-3
Objective	To make the students aware of different bye-laws and regulations pertaining to buidings and related projects.	
Modules	Introduction to Building Projects Project - formulation, appraisal and evaluation Project Management Issues Legal Issues Case studies - Urban housing and other building projects	

ENG(CBRI) 1-144	Industrialized Building Systems	L-T-P-C 3-0-0-3
Objective	To apprise the students about the newer techniques that are prevalent for the different types of building systems.	
Modules	Introduction Standardization Building Systems Strategies for Industrialization Prefabricated Systems for Building Envelopes Case studies and design	

ENG(CBRI) 1-146	Repair, Rehabilitation & Retrofitting of Structures	L-T-P-C 3-0-0-3
Objective	To impart knowledge about the techniques that are adopted for repair, rehabilitation and retrofitting of building structure.	
Modules	Condition Assessment of different types of buildings Innovative Repair Materials suitable for buildings Repair Techniques – Existing and innovative Quality Assurance and Control of old building structures Case Studies:- Buildings & Heritage structures	

ENG(CBRI) 1-148	Environmental Impact Assessment	L-T-P-C 3-0-0-3
Objective	To impart knowledge on the effect of constructed projects on the environment and systematic analysis of the same.	
Modules	Introduction and Scope Environmental Clearance Process in India Impact assessment Environmental Quality Standards Control measures Case Studies – Green Buildings	

ENG(CBRI) 1-150	Sustainable Design and Energy Efficient Building Systems	L-T-P-C 3-0-0-3
Objective	To make the students aware about the sustainable design concept and to generate awareness about the energy efficient building systems	
Modules	Introduction Challenges driving the need for Sustainable Design Building Performance Assessment Tools Insulation and Heat Transfer Case Studies - Integrated design process, Green / Sustainable design projects.	

ENG(CBRI) 1-152	Construction, Planning & Management	L-T-P-C 3-0-0-3
Objective	To make the students aware about the different techniques that are adopted in building construction practices and their management and usage of different construction equipments.	
Modules	Introduction - RCC and masonry system, pre-engineered and industrialized building system Planning Construction project management Estimation of project cost,	

ENG(CBRI) 1-154	Fire Protection Engineering	L-T-P-C 3-0-0-3
Objective	To impart knowledge on different aspects of fire protection in building system and schemes of disaster mitigation.	
Modules	Introduction to fire safety engineering Heat transfer mechanisms in fire & build up of untenability conditions Combustion flammability and retardency, Burning behaviour of materials Active and Passive fire protection	

ENG(CBRI) 1-156	Environmental Engineering & Management	L-T-P-C 3-0-0-3
Objective	To impart knowledge on different aspects of pollutants, thrie effect on the environment and efficient management system.	
Modules	Water and Wastewater Engineering. Air Quality and Modelling Solid Waste Management Emerging Technologies in Environmental Management Current trends and emerging technologies, contemporary issues.	

ENG(CBRI) 1-158	Advanced Seismology	L-T-P-C 3-0-0-3
Objective	To impart concepts on the basic aspects of seismic waves, their propagation, related instrumentation and consequences on the design of buildings	
Modules	Science of Earthquakes Seismic Waves, Magnitude & Intensity, Earthquake Source Mechanism, Seismic Instrumentation, Seismic Zoning Map, Site Response Studies, Source and Path effect, Seismic Hazard Analysis, Risk and estimation, Seismic Micro-zonation, Earthquake Prediction Studies, Seismic Alert Systems	

ENG(CBRI) 1-160	Engineering of Problematic Soil	L-T-P-C 3-0-0-3
Objective	To educate the students of geotechnical engineering on the different problematic soils and the techniques of remediation.	
Modules	Various problematic soils Difference between improvement and modification. Soft Soil Expansive Soil Loose Cohesionless Soil Various improvement techniques Organic Soil Contaminated Soil	

ENG(CBRI) 1-162	Optimization Techniques	L-T-P-C 3-0-0-3
Objective	To impart knowledge about the techniques that are adopted for optimising different design aspects related to building	
Modules	Introdiuction Types of optimization schemes Linear Optimization techniques Stochastic Programming etc	

ENG(CBRI) 1-164	Deep Excavation	L-T-P-C 3-0-0-3
Objective	To impart knowledge on the problems associated with excavation and design of large excavation.	
Modules	Introduction to the analysis and design of excavation Excavation methods and lateral supporting systems Lateral earth pressure Stability analysis Stress and deformation analysis of excavation Design of excavation supporting systems	

ENG(CBRI) 2-138	Health Monitoring of Building Structures	L-T-P-C 3-0-0-3
Objective	The objective of the course is to highlight the importance of monitoring techniques for effective maintenance of buildings and analysis methodologies	
Modules	Introduction monitoring systems of building Numerical modelling Experimental techniques Rehabilitation processes.	

ENG(CBRI) 3-136	Tall Buildings & Structures	L-T-P-C 3-0-0-3
Objective	To make the students aware about the analysis and design methodologies of tall buildings	
Modules	Introduction – Tall building systems – Analysis Methodology of tall building frames – Different types of loads multibay frames; Shear walls Coupled frames – Frame with shear wall; Principles of 3-D analysis of tall buildings; Perforated cores - Pure torsion, bending and warping of cores; Floor systems – Analysis; Elastic and inelastic stability of frames and shear walls; Analysis for Thermal Stresses; Other Tall structures.	

ENG(CBRI) 3-138	Behaviour of Metal Structures	L-T-P-C 3-0-0-3
Objective	To impart knowledge on the advanced techniques of analysing metal structures and to characterise their behaviour.	
Modules	Introduction Stability issues Thin plates and their use in buildings Steel columns and their behaviour with residual stress Use of light gauge structure Pre-stressing in steel structure.	

ENG(CBRI) 3-140	Rock Mechanics	L-T-P-C 3-0-0-3
Objective	To study the behaviour of rock at site under different stress conditions and to assess its properties in field and in the laboratory as well	
Modules	Introduction to rock mechanics Rocks, rock structures and their importance Surface and subsurface investigations Engineering rock mass classifications & their application Physico-mechanical properties of rocks Stresses in elastic and plastic ground conditions Excavation Methods Support design and instrumentation in tunnels and slopes Problems and their remedies in rock engineering Application of rock mechanics	

ENG(CBRI) 3-142	Landslide Disaster Mitigation	L-T-P-C 3-0-0-3
Objective	Study on landslide to understand its behaviour, design of slope and control measure design	
Modules	Introduction - Landslide Types and processes Application of Remote Sensing and GIS in Landslide studies Landslide Hazard and Risk Assessment Landslide Instrumentation SMR & Slope Stability Assessment – Landslide Control Measures Landslide case studies	

ENG(CBRI) 1-166	Laboratory - II Structural Engineering & Fire Engineering	L-T-P-C 0-0-4-2
Objective	To impart knowledge on the different aspects of advanced concrete structures and consequences of fire in structural systems.	
Modules	**Structural Engineering:** Experiments on concrete mix design, special concrete such as fiber concrete/geopolymer concrete; building dynamics; Non destructive tests- Schmidt hammer, UPV, corrosion analyzer, core cutting; Wind tunnel. **Fire Engineering:** Fire propagation index, Ignitability at various irradiances levels, Specific optical density of smoke, Toxicity index.	

ENG(CBRI) 2-137	Disaster Resistant Building System II	L-T-P-C 3-0-0-3
Objective	To impart knowledge on the techniques to designing buildings which will withstand landslide and earthquake	
Modules	**Landslide Disaster Mitigation:** Introduction - Landslide Types and processes - Landslide causes - Landslide Hazard and Risk Assessment - Landslide Investigation and failure mechanism - Landslide Instrumentation - Landslide Control Measures. **Earthquake resistant building structure**: Characteristics of earthquakes, analysis of structures for earthquake loading, Linear Analysis — Codal Method, Demand Capacity Ratio Method; Non-linear Pushover Analysis, Rapid visual screening and simplified evaluation of buildings, Strengthening of existing components — RC, Steel and FRP Jacketing. Introduction to Performance based Engineering Strategies. Introduction to Tsunami Disaster.	

CSIR-CEERI

ENG(CEERI) : 1-001 : Research Methodology : 1-1-0-2
Course Coordinator : Raj Singh

Introduction, terminology, and scientific methods; Types of research; Research process and steps; Identifying a research problem; Literature survey, appreciation of existing literature, identification of knowledge gaps; Conception of novel approach to solve the problem; Role of theory, modeling, and simulation; Design of experiments, testing and characterization strategies; Quantitative methods and data analysis; Qualitative analysis; Communicating research results; Thesis writing and oral presentation; Ethics in research.

ENG(CEERI) : 1-206 : Technical Communication : 2-0-0-2
Course Coordinator : Raj Singh

Role and importance of technical communication; Effective written and oral communication; Ethical issues; Technical report writing; Technical / R&D proposals; Research paper writing; Letter writing and official correspondence; Emails; Oral communication in meetings and group discussions; Oral presentations; Use of modern aids.

ENG(CEERI) : 2-206 : Project Management : 2-0-0-2
Course Coordinator : Raj Singh

Introduction; Project formulation, evaluation and initiation; Project planning and scheduling; Risk management; Project execution and implementation; Project monitoring and control; Project closure; Project documentation; Leadership and teamwork issues; Complex projects; Advances and trends.

ENG(CEERI) : 2-208 : System Design for Process Control Applications : 3-0-0-3
Course Coordinator : S. S. Sadistap and B. A. Botre

Virtual instrumentation and measurements, Virtual instrument design approach using LabView; Data acquisition modules; Electronic system trends, design options, metrics and considerations; Electronic system development cycle; PIC family of microcontrollers based system design and programming; Interfacing techniques for memory and I/O devices; Process control and instrumentation; Process simulation and modeling; Design case studies.

ENG(CEERI) : 2-209 : System Modeling and Design Languages : 3-0-0-3
Course Coordinator : K. Solomon Raju and Rahul Varma

Overview of the system specification, modeling and design methodologies; Untimed model of computation; Synchronous model of computation; Timed model of computation; Modeling of computation interfaces; Basic concepts of system design specification, modeling and simulation using VHDL, SystemC, and UML; Transaction

level modeling (TLM) based methodologies; Fundamentals of system design using Saber.

ENG(CEERI) : 2-210 : Intelligent Sensor Systems : 3-0-0-3
Course Coordinator : P. C. Panchariya and P. Bhanu Prasad

Primary sensing principles and measurement variables; Sensor performance characteristics and terminology; Transducer measurement circuits; Signal conditioning circuits; Data conversion; Virtual instrumentation with LabView; Introduction of soft-computing techniques; Foundations of fuzzy approaches; Fuzzy rule based systems; Fundamentals of neural networks; Implementation of various learning algorithms; Competitive, associative and other special neural networks; Practical aspects of neural networks; Neural methods in fuzzy systems; Introduction to statistical pattern recognition; Dimensionality reduction; Classification; Validation; Data analysis with MATLAB; Introduction to intelligent sensor system and their structures; Advanced processing and control techniques; Smart sensors; Case study: the “electronic nose”; The future of intelligent sensor systems.

ENG(CEERI) : 2-211 : Real-time Embedded System Design : 3-0-0-3
Course Coordinator : K. Solomon Raju

Fundamentals of FPGA-based system design, Architecture of embedded processors, Advanced processor architecture concepts, architectures for digital signal processing and applications; Designing soft processors with FPGAs; Power/energy efficient embedded system design; Real-time programming and communication; Concurrent Programming, Synchronization and communication; Scheduling of uni-processor and multi-processors; Real-time operating systems (RTOS) organization, Concept of kernel design, RTOS scheduling, Case studies of VxWorks, QNX, TinyOS, and others; Programming with QNX or VxWorks; Embedded hardware building blocks, Embedded system level design, design space exploration and verification techniques.

ENG(CEERI) : 2-212 : Advanced Signal and Image Processing : **3-0-0-3**
Course Coordinator : J. L. Raheja and A. Karmakar

Discrete-Time Signals and systems in time domain; Time-domain characterization of Linear Time Invariant (LTI) Discrete-Time Systems (DTS); Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), z-transform; LTI DTS in the frequency domain : transfer function, frequency response; Simple digital filters; 2-D filters; FIR and IIR filter design; DSP algorithm implementation issues and finite word length effects; Image sensor models; Image representations and properties; Noise models, Image de-noising, Image pre-processing; Segmentation, Histogram, Histogram equalization and its application; Edge detection algorithm; Motion detection algorithm; Application of edge, face and motion detection; Hough transform and its application.

ENG(CEERI) : 2-213 : Power Electronics and AC/DC Drives : 3-0-0-3
Course Coordinator : Rahul Varma and A. K. Dhakar

Power Electronics : Need of Power conversion, Applications of power electronics; Power semiconductor devices : Diode, Thyristor, MOSFET, IGBT; Line frequency diode rectifiers; Switch-Mode DC-DC Converters : Introduction, Step-down (buck), Step-up (boost), Buck-boost, full-bridge DC-DC converter and comparison; Introduction of high-frequency inductors and transformers; Switch-mode DC-AC inverters : Single-phase, three-phase inverters, Effect of Blanking time; Switching DC power supplies : Overview of switching power supplies, DC-DC converters with electrical isolation, Control of switch-mode DC power supplies, Electrical isolation in the feed-back loop, designing feedback controllers in switch-mode DC power supplies; Power factor correction (PFC) Circuits; Introduction of soft-switching in DC-DC Converters; Introduction to electric drive systems. Understanding mechanical system requirements for electric drives; Basic principles of electro-mechanical energy conversion; DC motor drives and electronically-commutated motor drives; Introduction to AC machines and space vectors; Induction motors : balanced, sinusoidal steady-state operation and speed control.

ENG(CEERI) : 2-215 : Process Control Applications Laboratory : 0-0-4-2
Course Coordinator : B. A. Botre and S. S. Sadistap

Laboratory practices and safety considerations; LabView usage and programming; Data acquisition module programming; Using PIC family of microcontrollers for electronic systems design; Buses and Interfacing memory and I/O devices; Process simulation and modeling.

ENG(CEERI) : 2-216 : System Modeling Laboratory : 0-0-4-2
Course Coordinator : K. Solomon Raju, Pramod Tanwar and Rahul Varma

Laboratory practices and safety considerations; Understand Xilinx FPGA architecture; Introduction to designing with Xilinx FPGAs using Xilinx EDK, Core Generator; Architecture wizard and pin assignment; ChipScope; Design of DSP sub-blocks using SysGen; Designing system blocks using synthesis tools; System design using Saber tools for various applications.

ENG(CEERI) : 2-217 : Intelligent Sensor Systems Laboratory : 0-0-4-2
Course Coordinator : P. C. Panchariya and Santosh Kumar

Laboratory practices and safety considerations; Sensor interfacing; Signal conditioning of various sensors such as temperature, gases, pressure, humidity etc.; sensor calibration and excitation; Data acquisition; Virtual instrument and GUI design; Analog and digital I/O; File I/O; Integration of sensor, DAQ and GUI modules; implementation of pattern analysis methods; Signal preprocessing; Dimensionality reduction; Classification; Implementation of Fuzzy systems; Implementation of neural network

algorithms; Time series forecasting; Implementation of neuro-fuzzy algorithms on real-world data sets.

ENG(CEERI) : 2-218 : Real-time Embedded System Design Laboratory : 0-0-4-2
Course Coordinator : K. Solomon Raju and Pramod Tanwar

Laboratory practices and safety considerations; Understanding of developing a PowerPC and MicroBlaze based embedded system by using Xilinx Embedded Development Kit (EDK); Basic hardware design steps; Adding a processor system to a FPGA Design; Adding IP to a hardware design; Adding custom IP to the bus; writing software applications; System simulation with RTOS support; Multi-processor system design and implementation.

ENG(CEERI)32 : 2-219 : Advanced Signal and Image Processing Laboratory : 0-0-4-2
Course Coordinator : J. L. Raheja and A. Karmakar

Laboratory practices and safety considerations; MATLAB experiments on LTI systems in time and frequency domain, transfer function, frequency response; Design of digital FIR filters using windowing, frequency sampling; Design of digital IIR filters using impulse invariant, bilinear transform method; Two-channel and multi-channel orthogonal filter bank design; MATLAB experiments on color space conversion, basic image processing operations; Implementing various edge detection techniques; Real-time implementation of edge detection using DSP board; MATLAB experiments on histogram equalization, face detection and motion detection.

ENG(CEERI) : 2-220 : Power Electronics and AC/DC Drives Laboratory : 0-0-4-2
Course Coordinator : A. K. Dhakar

Laboratory practices and safety considerations; Familiarization with power electronic components, Line frequency diode rectifiers, Different PWM techniques, Switch-mode DC-DC Converters, Single-phase and three-phase inverter, DC-DC isolated converters, Speed control of DC motor, Brushless DC motor drive, AC motor drives.

ENG(CEERI) : 2-221 : Physics of Semiconductor Materials and Devices : 4-0-0-4
Course Coordinators : J. Akhtar and S. C. Bose

Semiconductors; Inorganic and organic, single crystalline, polycrystalline, porous, amorphous crystal structures, and material properties; Si, GaAs, GaN, SiC; Energy band diagrams; Dielectric constant, permeability, permittivity, sheet resistance, resistivity, mobility, thermal conductivity and heat dissipation; Piezo-resistive and piezo-electric effects; Defects, dislocations and micro-plasma, phonon dynamics, ion-solid

interactions; Electron transport in semiconductors, minority carrier life time, avalanche breakdown phenomena, Hall effect; Theory of p-n junction, Schottky barrier, MOSFETs and MESFETs, IMPATTs and BARRITTs; Hetro-structures, strained semiconductors; Photovoltaics and solar cell; Solid state sensors and transducers; MOS analysis.

ENG(CEERI) : 2-222 : Unit Processes in Semiconductor Technologies : 3-0-0-3
Course Coordinator : G. Eranna

Crystal growth techniques, wafer preparation and shaping, chemical cleaning, thermal oxidation, photo-lithography, chemical etching (wet and dry), chemical vapor deposition techniques, thermal diffusion, ion implantation, metalization, chemical mechanical polishing, rapid thermal processing.

ENG(CEERI) : 2-223 : CMOS Digital VLSI Design : 3-0-0-3
Course Coordinator : A. Karmakar

Introduction to MOSFET from designer's viewpoint; MOS inverter : static and switching characteristics; MOS capacitor; Layers in VLSI design; Design rules and technology interface; Stick diagrams and Layout design; Propagation delay, Fan-out consideration; CMOS Latch-up; Scaling; Combinational MOS logic circuits : pass-transistors/transmission gates, primitive logic gates, complex logic gates; Sequential MOS logic circuits : latches and flip-flops; Dynamic logic circuits; Clocking issues; CMOS subsystem design.

ENG(CEERI) : 2-224 : Characterization Techniques for Semiconductor Materials, Technology and Devices : 3-0-0-3
Course Coordinator : K. J. Rangra and G. Eranna

Resistivity, Contact resistance, barrier height, carrier and doping concentration, mobility and carrier life time measurement techniques; Test structures for technology characterization; Analysis of surfaces, interfaces, thin films and devices; E-beam based techniques, Scanning Electron Microscopy and allied techniques; Material analysis techniques; Scanning probe Techniques; Ion-beam based techniques; Interferometry based techniques for materials and device characterization; Optical characterization.

ENG(CEERI) : 2-225 : Semiconductor Processing Technologies Laboratory : 0-0-4-2
Course Coordinator : G. Eranna

Laboratory practices and safety considerations; Wafer preparation and shaping; Chemical cleaning; Thermal oxidation, photo-lithography; Wet chemical etching; Dry etching; Chemical vapor deposition; Thermal diffusion; Ion implantation; Metalization.

ENG(CEERI) : 2-226 : CMOS-based Physical Design Laboratory : 0-0-4-2
Course Coordinator : A. Karmakar

Laboratory practices and safety considerations; SPICE simulation; Schematic editor, Layout editor, DRC, LVS; Transfer and output characteristics NMOS transistor, parameter variations; CMOS inverter design, inverter threshold, noise margin, propagation delay; Layout of CMOS inverter, n-well design rules, LVS, static and transient characteristics, DRC; 2-input NAND/NOR gate; D latch and flip-flop; Post-extract simulation.

ENG(CEERI) : 2-227 : Semiconductors Related Characterization and Measurement Techniques Laboratory : 0-0-4-2
Course Coordinator : K. J. Rangra and G. Eranna

Laboratory practices and safety considerations; IV and CV Measurements; Resistivity, thickness, thin-film surface and bulk defects; grain size measurement; AFM/STM surface analysis; Stress and deformation measurements; Measurement of sheet resistance, junction depth, carrier mobility, doping profile estimation, minority carrier life-time measurement; Model parameter extraction experiments.

ENG(CEERI) : 2-228 : HDL-based Digital Design Laboratory : 0-0-4-2
Course Coordinator : A. S. Mandal

Laboratory practices and safety considerations; Introduction to HDLs; Simulation of behavioral, Architecture/RTL, data-flow and structural HDL code; Sub-system design using HDL : various adder architectures, BCD arithmetic, various counters, traffic-light controller, *etc.*; Mini-project. *(SystemC, VHDL and/or SystemVerilog will be used as the HDL for the laboratory.)*

ENG(CEERI) : 2-231 : Electromagnetic Theory and Transmission Lines : 4-0-0-4
Course Coordinator : A. K. Sinha

Maxwell's equations; Wave equations and their solutions; Boundary Conditions and their applications; Electromagnetic energy and power flow; Poynting theorem. Transmission lines; Wave-guide and coaxial components. Scattering matrix representation; Propagation of electromagnetic waves through homogeneous, in-homogeneous, and anisotropic media. Surface resistance and RF resistance. Ferrite devices. Waveguides and resonators. Characteristic and interaction impedances. Quality factors (loss and diffractive). Impedance Matching. Measurement of "Q", power, noise figure, S-parameters, dielectric constant and loss tangent, dispersion and impedance characteristics, and loss parameters.

ENG(CEERI) : 2-232 : Microwave Communication : 2-0-0-2
Course Coordinator : V. V. P. Singh

Ground/surface wave, space-wave, and sky-wave modes of communication; Tropo-sphereic Communication; Line of sight communication and system performance; Active and passive repeaters and their design; Analog and digital communication; Mobile communication; Satellite communication system; Earth station design criteria and direct

reception system; Satellite transponders and their design criteria; PhPHY(CEERI)-noise, intra-pulse and inter-pulse noises and their significance.

ENG(CEERI) : 2-233 : Numerical Techniques and CAD of Microwave Tubes : 4-0-0-4
Course Coordinator : V. Srivastava

Numerical solution of linear and non-linear differential equations of higher orders; Analytical and numerical techniques to the solution of electromagnetic field problems; Numerical techniques for the electrical, thermal, and structural design of slow-wave and fast-wave microwave tubes; Spent beam analysis for efficiency enhancement; Special focusing techniques for multi-beam electron guns; PIC simulation techniques; Finite difference and finite element techniques; Method of moments applied to microwave devices.

ENG(CEERI) : 2-234 : Microwave and Millimeter-Wave Tube Technology : 3-0-0-3
Course Coordinator : R. S. Raju

Fundamentals of vacuum technology. Vacuum generation and measurement, and leak detection. Ultra-high vacuum techniques. Surface physics and analysis in relation to electron Emitters. Electron-tube grade materials and their characteristics. Chemical processing. Heat treatment and special techniques: brazing, sintering, sputtering, TIG/electron beam/laser welding, glass-to-metal and ceramic-to-metal sealing, loss coating, and helix fitting. Vacuum processing of integrated devices. Design of tools, jigs, and fixtures. Engineering / mechanical design of components. Special machining techniques.

ENG(CEERI) : 2-235 : Microwave Components Characterization and Tube Processing Techniques Laboratory : 0-0-6-3
Course Coordinator : O. S. Lamba

Laboratory practices and safety considerations; Scattering parameters; Measurement of impedance and characterization of cavities; Dispersion and impedance characterization of RF structures; RF loss measurements; UHV techniques; Heat treatment in protective atmosphere; Ceramic-to-metal sealing techniques; Chemical processing of components.

ENG(CEERI) : 2-236 : Microwave Devices Characterization and Tube Sub-assembly Fabrication Laboratory : 0-0-6-3
Course Coordinator : L. M. Joshi

Laboratory practices and safety considerations; Device characterization using spectrum analyzer, scalar/vector analyzer; Break-down tests; X-ray radiography; Cathode characterization using Auger and Thermal emission microscope; Hot RF characterization of devices; Metal-to-metal brazing techniques; Leak detection; TIG/laser welding; Vacuum processing of devices; Cathode fabrication.

ENG(CEERI) : 3-001 : Advanced Self-study (Special Topic) : 0-2-4-4
Course Coordinator : Senior Scientists

This will involve readings from published literature or books about new frontiers on a specific topic related to the field of electronics under guidance of senior scientist(s). A report needs to be submitted and a seminar on the special topic needs to be presented.

ENG(CEERI) : 3-211 : MEMS Technology, LTCC and Packaging : 3-0-0-3
Course Coordinator : B. D. Pant and P. K. Khanna

Review of Silicon crystal and unit processes; Processing steps for MEMS device fabrication; photo-lithography and backside mask alignment; Surface and bulk micro-machining techniques; Deep reactive ion etching; LIGA process; Wafer-level bonding and packaging techniques; LTCC technology, materials, LTCC process steps, bonding and packaging; Testing and characterization of technology; Reliability and residual stress issues.

ENG(CEERI) : 3-212 : Physics and Design of MEMS and Microsensors : 3-0-0-3
Course Coordinator : Ram Gopal and K. J. Rangra

Overview of Microsensors; Mechanical properties of materials and essentials of structural mechanics; Electro-mechanical, magneto-mechanical and piezo-based sensing; Structural elements for MEMS and microsensors (Beams, plates, cantilevers, bridges and diaphragms); Electrostatic sensing and actuation (parallel plate and torsional structures, time domain analysis); Micro-fluidics; Scaling laws and miniaturization; Micro-system design principles; MEMS simulation and design Tools; RF MEMS; Reliability issues in microsensors; Examples and applications of MEMS microsensors.

ENG(CEERI) : 3-213 : Nanoelectronic Devices and Technologies : 3-0-0-3
Course Coordinator : Anil Kumar

Low-dimensional structures (Quantum well, quantum wire, quantum dot, quantum confinement); Confinement energy level, band-gap enhancement, absorption-emission spectra, blue shift, luminescence; Nanoelectronic Devices (Single electron box, Coulomb blockade, single electron transistor, pump, turnstile, trap, memory); Simulation, Modeling of single electron devices and applications; Technology for fabrication of nanostructures and nanoelectronic devices; Next generation lithography techniques; Characterization of nanoscale materials and nanodevices.

ENG(CEERI) : 3-214 : Advanced VLSI Technologies and Devices : 3-0-0-3
Course Coordinator : G. Eranna and W. R. Taube

Overview of VLSI technology; Effect of scaling on MOS devices and interconnections; Hot electron degradations and drain engineering structures; Process and material

requirements for VLSI devices; Advanced thin-film deposition and VLSI process techniques; High-k dielectric and low-k dielectric materials; Process integration of high-k metal gate for nanoscale CMOS technology; Device characterization, failure diagnosis and reliability measurements; Carrier transport mechanisms, velocity saturation, ballistic transport; Nanoscale MOSFET, FinFET and Multi-gate FET; Emerging materials and future devices.

ENG(CEERI) : 3-215 : CMOS Analog Design : 3-0-0-3
Course Coordinator : S. C. Bose

Basic concepts of transistors and diodes, their modeling, large-signal and small signal analysis, CMOS technology, clock feed-through; Reference sources : bias circuits, band-gap reference circuit, cascode current mirror; Single-stage amplifier, common source amplifier, drain and gate amplifier, differential amplifier; Operational amplifier; Comparators; Switched-capacitor circuits; Introduction to data converters; Issues of analog layout and device noise.

ENG(CEERI) : 3-216 : Advanced VLSI System Architectures : 3-0-0-3
Course Coordinator : A. S. Mandal

Introduction and review of basic computer architectures, CISC and RISC processors; Pipelining, hazards, exception handling, optimization techniques, synchronous and asynchronous pipelining; Memory organization, caches, virtual memory, memory management; Arithmetic circuits, algorithms and architectures for high-radix adders, multipliers, sine-cosine and exponential computation; Instruction-level parallelism, super-scalar, super-pipelined and VLIW architectures, array and vector processors; Multiprocessor architectures and parallel architectures, synchronization, memory consistency; DSP architectures; Performance improvement techniques; ASIP; Low-power architectures; Fault-tolerant architectures; Case-study on Algorithm-to-Architecture; Future trends.

ENG(CEERI) : 3-217: Optoelectronic Materials, Devices and Technologies : 3-0-0-3
Course Coordinator : C. Dhanvantri

Optoelectronic Materials; Growth of Epitaxial materials; Characterization of Epitaxial Materials; Optoelectronic Devices (Light Emitting Diodes, Semiconductor Lasers, UV, Visible and IR Photo-detectors and Receivers, Solar Cells); Compound semiconductors and advanced electronic devices; Compound Semiconductor Technologies; Packaging of compound semiconductor components; Applications and trends.

ENG(CEERI) : 3-218 : Photonic Materials, Devices and Technologies : 3-0-0-3
Course Coordinator : S. Pal

Introduction to Photonics; Basic photonic components and their technologies; Propagation of Electromagnetic waves; Optical waveguides and optical fibers; Principle of optical fiber communications, Transmission capacity, Dispersion and losses in optical

fiber; Coupled mode theory in guided wave systems; Materials and fabrication technologies; Types of waveguides; Basic photonics devices and components; Optical sensors and sensing techniques; Optical MEMS; Fiber gratings and waveguide gratings; Photonic crystal based waveguides and devices; Packaging of photonic devices; Applications of photonic devices; Recent trends.

ENG(CEERI) : 3-221 : MEMS Technology, LTCC and Packaging Laboratory : 0-0-4-2
Course Coordinator : B. D. Pant and P. K. Khanna

Laboratory practices and safety considerations;; Wafer cleaning; Lithography : front and backside alignment; Bulk micro-machining; DRIE process; LPCVD; Metalization; Wafer bonding; Surface planarization; Wafer dicing; LTCC process; Packaging.

ENG(CEERI) : 3-222 : Design of MEMS and Microsensors Laboratory : 0-0-4-2
Course Coordinator : Ram Gopal and K. J. Rangra

Laboratory practices and safety considerations; MEMS design tools; Design of pressure sensors of various types; Design of gas sensors of various types; Acoustic, Ultrasonic, micro-resonator, ISFET; RF MEMS design and simulation.

ENG(CEERI) : 3-223 : Nanoelectronic Technologies Laboratory : 0-0-4-2
Course Coordinator : Anil Kumar

Laboratory practices and safety considerations; Fabrication of metal thin films by sputtering/e-beam/resistive-heating and measurement of film thickness by making steps using wet etching; Experiments on growth of Silicon nanoparticles and their optical characterization; Experiments with nanolithography and nanopatterning; Simulation of single electron devices using SIMON; Simulation of inverter circuit using SET in SIMON; Operation of AFM/STM; Analysis of AFM/STM images; Study of annealing effect on roughness/grain size of metal films by AFM/STM imaging and analysis.

ENG(CEERI) : 3-224 : Study and Seminar on Advanced VLSI Technologies : 0-0-4-2
Course Coordinator : G. Eranna and W. R. Taube

This will involve literature search, review and study of current research on materials, process methodologies and simulations, and novel applications related to advanced VLSI technologies and nanoelectronics. Simulation studies and experiments may also be carried out, where possible. A study report is to be submitted and a seminar is to be given.

ENG(CEERI) : 3-225 : CMOS Analog Design Laboratory : 0-0-4-2
Course Coordinator : S. C. Bose

Laboratory practices and safety considerations; I-V characteristics of MOSFET, estimation of early voltage; Clock feed-through and its minimization; Bias generation architecture simulation; Band-gap reference circuit simulation; Design and simulation of various amplifiers; Design and simulation of 2-stage CMOS operational amplifier; Layout of analog circuits.

ENG(CEERI):3-227 : Optoelectronic Devices and Technologies Laboratory : 0-0-4-2
Course Coordinator : C. Dhanvantri

Laboratory practices and safety considerations; Lift-off process for Ohmic Contact on GaAs substrate; TLM measurements for specific contact resistance; RIE process for GaAs etching; LI Characteristics of 980 nm Laser Diode; Transistor characteristics of GaAs Power MESFET; LED Characteristics; Photoluminescence characterization of GaN epitaxial material; Characterization of PIN-FET receiver module.

ENG(CEERI) : 3-228 : Photonic Devices and Technologies Laboratory : 0-0-4-2
Course Coordinator : S. Pal

Laboratory practices and safety considerations; Measurement of refractive index and thickness of planar waveguides; Propagation loss measurement of planar waveguides; Design of 1x2 and 1x4 optical power splitter; Measurement of insertion loss, uniformity and polarization-dependent loss of a packaged 1x8 optical splitter at C+L band region; Design and simulation of Bragg gratings; Waveguide patterning by photo-lithography; Testing of MUX/DEMUX by DWDM test set-up; Chip-level testing: alignment of DUT (in a diced chip) to the source and the detector with x-y-z alignment stages.

ENG(CEERI) : 3-231 : Slow-wave Devices – Principles and Design : 4-0-0-4
Course Coordinator : V. Srivastava and L. M. Joshi

Classification and high frequency limitations of conventional electron tubes. Formation and confinement of an electron beam. Slow-wave structures, couplers and RF windows. Beam-wave interaction mechanism. Spent beam collection. Efficiency enhancement by phase-velocity tapering and multi-stage depressed collection. Different types of devices, their operation, and characteristics, High power and wide bandwidth issues. Future trends.

ENG(CEERI) : 3-232 : Fast-wave Devices – Principles and Design : 3-0-0-3
Course Coordinator : A. K. Sinha

Merits of fast-wave devices over slow-wave devices. Operating principle of a gyrotron and design of its components: magnetron injection gun, beam tunnel, RF interaction cavity, magnetic field, non-linear taper, RF window, mode converter and collector.

Beam-wave interaction and mode selection criteria. Other fast-wave devices: gyro-TWT, gyro-klystron, peniotron and FEL. Applications of gyro-devices and future trends. High Power Microwave (HPM) Devices.

ENG(CEERI) : 3-233 : CAD of Microwave Tubes Laboratory : 0-0-4-2
Course Coordinator : R. K. Sharma and S. K. Ghosh

Laboratory practices and safety considerations; Components design : electron guns, slow-wave structures, fast-wave structures, RF cavities, RF windows, collectors; Electron beam and RF wave interaction simulation; Thermal and structural design and simulation; CAD of complete tube; Computer aided engineering drawing.

ENG(CEERI) : 3-234 : High Power Microwave Systems and Applications : 3-0-0-3
Course Coordinator : L. M. Joshi

Special EW (Radar, ECM, ECCM) systems and their requirements in respect of microwave and millimeter wave devices; Types of jamming; Linear accelerators, Microtrons, Synchrotrons, Plasma heating systems, Proton accelerators, and Thermonuclear reactors; Other applications like imaging, spectroscopy, biomedical, industrial heating, electronic power conditioners, and modulators.

ENG(CEERI) : 3-235 : Electron Emitters and Surface Characterization : 2-0-0-2
Course Coordinator : R. S. Raju

Physics of electron emission, emission equation; Temperature limited and space-charge limited emission; Methods of determining work function; Oxide coated cathodes, Dispenser cathodes, Field emitters, Explosive emission cathodes, Secondary emitters; Fabrication and characterization of cathodes; Life testing and surface analysis techniques; Nano-cathodes.

ENG(CEERI) : 3-236 : Plasma-Filled Microwave Sources : 2-0-0-2
Course Coordinator : Ram Prakash and U. N. Pal

Plasma and its physical parameters; Saha equation and its relevance; Motion of charged particles in static and slowly varying electric and magnetic fields; Motion of relativistic charged particles; Types of gaseous discharge; Hollow-cathode discharge and other kinds of low-pressure discharges; General features of electrons emission, control and extraction of electrons and ions from plasma in DC and pulsed mode conditions; Plasma sources for axially symmetric electron beams; Plasma cathode electron gun (PCE-gun); Advantages of plasma filling in high power microwave devices; Operating principles, characteristics, and applications of different types of plasma-filled devices including the pasotron.

ENG(CEERI) : 3-237 : Vacuum Microelectronic Devices : 2-0-0-2

Course Coordinator : R. K. Sharma

Basic semiconductor technologies like reactive ion etching, photo-lithography, oxidation, CVD, sputtering, LIGA; MEMS technologies; Design considerations in vacuum microelectronic devices; Photonic band-gap structures, folded wave guide and ladder structures; Tera Hertz devices including reflex klystrons; Micro-fabricated devices like TWT and klystrino; Combination of vacuum and semiconductor technologies in microwave devices, including microwave power module and their applications.

ENG(CEERI) : 4-001 : Project Proposal Writing : 0-1-6-4
Course Coordinator : Raj Singh

Definition of a scientific project proposal; Components of a proposal; Need and purpose of the proposal; Aims and objectives; Background and present status; Proposed methodologies and approaches; Scheduling and mile-stones; Resource allocation; Budgeting; Monitoring and evaluation mechanisms; Referencing and citing; Use of data, graphs, tables, figures; Proposal funding agencies and their formats.

Every student needs to submit two proposals – one related to PhD research topic and the second in any field of electronics.

ENG(CEERI) : 4-002 : CSIR-800 Societal Programme : 0-0-8-4
Course Coordinator : Raj Singh

A project needs to be undertaken in rural area for 6-8 weeks duration aligned to the CSIR-800 programme. The theme of the project may be chosen from the CSIR-800 document or from any other government department related to benefiting and empowering the economically lower 800 million Indians by way of S&T innovations. The aim is to interact with underprivileged people in the villages and propose solutions in the area of health, agriculture, energy, water, food, education, *etc.*

CSIR-CMMACS

ENG (CMMACS)- 1-001: Research Methodology : 1-1-0-2
Course Coordinator: P Goswami

Introduction, Research terminology and scientific methods, different types and styles of research, role of serendipity, creativity and innovation, Scientific and critical reasoning skills, art of reading and understanding scientific papers, literature survey. Measurements in research - primary and secondary data. Quantitative methods and data analysis, Qualitative analysis, Communicating research results. Designing and implementing a research project. Ethics in research, Plagiarism, Case studies. Laboratory safety issues – lab, workshop, electrical, health & fire safety, safe disposal of hazardous materials.

Role & importance of communication, Effective oral and written communication. Technical report writing, Technical/R&D proposals, Research paper writing, Dissertation/Thesis writing, Letter writing and official correspondence. Oral communication in meetings, seminars, group discussions; Use of modern aids; Making technical presentations.

ENG(CMMACS)-2-416: Transport Phenomena: 2-1-0-3
Course Coordinator: **Partha Sarathi Goswami**

Introduction to engineering principles, units and dimensional analysis, overview of basic mathematics (vectors, tensors etc).

Molecular and convective transports, Shell balances: Mass, Momentum and energy balances, Navier Stokes equations, Potential and viscous flows.

Approximations in fluid mechanics: pseudo steady state and lubrication, inter-phase transport coefficients, unsteady state microscopic balances for mass, momentum and energy transport.

Recommended Books

- Bird, R.B, Stewart, W.E. and Lightfoot, E.N., Transport Phenomena, Wiley, 1994.
- Denn, M.M, Process Fluid Mechanics, Prentice Hall, 1980.
- Whitaker, S., Fundamental Principles of Heat Transfer, NewYork, Pergammon, 1997.
- Cussler, E, L., Diffusion. Mass Transfer in Fluid Systems, Cambridge, 1985.

ENG(CMMACS)-2-417: Finite Element Method: 3-0-0-3
***Course Coordinator:* P Seshu**

Approximate solution of linear differential equations -- Weighted residual techniques. Collocation, Least Squares and Galerkin methods. Use of piecewise continuous approximation functions. Basis of Finite Element Method. Formulation of element level equations and assembly into system level equations. One dimensional example problems.

Elements of Variational calculus. Minimisation of a functional. Principle of minimum total potential. Piecewise Rayleigh - Ritz method and FEM. Comparison with weighted residual method.

Two dimensional finite element formulation. Isoparametry and numerical integration.

Finite element formulation for transient dynamic problems.
Algorithms for solution of equations.

Recommended Books

1. Bathe, K. J., Finite element procedures in Engineering Analysis, Prentice Hall of India, 1990.
2. Cook R.D., Malkus. D. S., Plesha M. E. and Witt R. J, Concepts and Application of Finite Element Analysis, 4th Ed., John Wiley, 2005.
3. Huebner K. H., Dewhirst D. D., Smith D. E. and Byrom T. G., The Finite Element Method for Engineers, John Wiley, New York, 2004.
4. Reddy J. N., An Introduction to the Finite Element Method, 3rd Ed., Tata McGraw Hill, New Delhi, 2005.
5. Seshu P., Finite Element Analysis, Prentice Hall of India, 2003.
6. Zienkiewicz, O. C., and K. Morgan, Finite elements and approximation, John Wiley, 1983.
7. Zienkiewicz O. C, Taylor R. L. and Zhu J Z., The Finite Element Method: Its Basis and Fundamentals, 6th Ed., Elsevier, 2005

ENG(CMMACS)-2-418: Statistical and Computational Methods: 2-1-0-3
Course Coordinator: N K Indira

Basic Concepts: Discrete and continuous data, Sample and Population, Events and Probability, Frequency, Table and Frequency distribution, Random variable and expectations, Measures of central tendency, dispersion and coefficient of variation, Moments and moment generating functions.
Regression and Correlation: Linear regression analysis, Nonlinear regression analysis, Multiple regression Correlations.

Probability and probability distributions: Discrete probability distributions and Continuous Probability distributions.
Classical Time series analysis: Measurement of trend, Measurement of seasonal fluctuations, Measurement of cyclic fluctuations.
Stochastic time series analysis: System definition, System analysis, Model formulation, Modelling procedure, Estimation and validation.
Correlation systems: Principal component analysis, Factor analysis. Analysis of variance. One way classification and Two way classification. Statistical analysis and hypothesis testing. Sampling and sampling distributions, Parametric estimation, Tests of hypothesis, Nonparametric method.

Recommended Books:

1. Goon,A.M.; Gupta, M.K. And Dasgupta, B. An Outline of statistical theory.
2. Goon,A.M.; Gupta, M.K. And Dasgupta, B. Fundamentals of Statistics.
3. Hogg,R.V. And Craig,A.T. Introduction of mathematical statistics.
4. Box, G.E.P and Jenkins, G.M Time series analysis forecasting and control
5. Fulury, B.Common Principal component and related multivariate models
6. Nelson, C.R. Applied time series for forecasting
7. Irving W.B. Applied Statistical methods
8. Patel J.K.; kapadia,C.H. And Owen D.B Handbook of statistical distributions
9. Mood, A.M; Graybill, G.C Introduction to the theory of statistics

ENG(CMMACS)-2-419: Global Navigation Satellite System (GNSS) theory and it applications: 2-1-0-3

Course Coordinator Sridevi Jade

Introduction to GNSS geodesy, GNSS theory, GNSS reference frames, sources of errors and correction, positioning using GNSS observables, GNSS data collection, data processing and analysis, GNSS applications for Geoscience, Modelling of GNSS derived surface deformation.

Introduction to GNSS geodesy covers the state of art on Global Navigation Satellite systems, its components, geodesy, Military and Civil applications. GNSS reference frames: Introduction to celestial and terrestrial reference frames, Earth Centered Earth fixed reference frame and earths pole of rotation. Sources of errors and corrections: Introduction of positioning using GNSS satellites, errors involved covering orbit, clock errors, troposphere and ionosphere errors, miscellaneous errors. Positioning using GNSS observables: To determine the precise position and time, error correction, different types of positioning. GNSS data and processing theory: Models involved in data processing and analysis. GNSS applications to Geoscience: Surveying, continental deformation studies, landslide hazard mapping, Glacier dynamics, Volcano deformation, troposphere and ionosphere modeling, InSAR (Interferometric Synthetic Aperture Radar), GIS (Geographical Information System) etc. Modelling of GNSS deformation: brief introduction of different kind of modeling techniques that are currently being used.

Recommended Books:

1. GPS Theory and Practice – B. Hofmann-Wellenhof, H. Lichtenegger and J.Collins
2. Introduction to GPS – Ahmed E1-Rabbany
3. Principles of GPS – P.S. Dhunta
4. Global Positioning System: Theory and Applications I & II Parkinson and Spilker
5. GPS Satellite Surveying – Leick

ENG(CMMACS)-2-420: Principles and Techniques of Mathematical Modelling: 2-1-0-3

***Course Coordinators:* V Y Mudkavi**

This course will provide an overview of principles and techniques of mathematical modelling used by engineers and scientists with a bias to fluid mechanics. The following topics will be discussed:

1. Mathematical modelling. What is modelling? Properties of a model. Why do we model? Some examples. The four paradigms and relevance of modelling.
2. Order of magnitude analysis. Dimensional arguments.
3. Complex variable. Power series. Branch points.
4. Vectors and tensors. Linear vector spaces. Matrix theory.
5. Vector fields, their Divergence and Curl. Classification and representation of vector fields.
6. Numerical methods. Numerical differentiation and integration. Interpolation. Initial and boundary value problems. Euler and Runge-Kutta methods. Multi-step methods.
7. Dynamics: Geometric ideas.
8. Model equations in fluid mechanics.

Recommended Books

1. Bender, E. A. *An Introduction to Mathematical Modeling.* John Wiley and Sons. 1978.
2. Goldreich, P., Mahajan, S., Phinney, S. *Order-of-Magnitute Physics: Understanding the Wold with Dimensional Analysis, Educated Guesswork, and White Lies.* 1999.
3. Nearing, J. *Mathematical Tools for Physics.* www.physics.miami.edu/nearing/mathmethods/. 2003.
4. Koonin, S. E. *Computational Physics.* Benjamin/Cummings. 1986.
5. Golub, G. H., Ortega, J. M. *Scientific Computing and Differential Equations: An Introduction to Numerical Methods.* Academic Press. 1992.
6. Aris, R. *Mathematical Modelling Techniques.* Dover. 1995.
7. Abraham, R. H., Shaw, C. D. *Dynamics: The Geometry of Behavior.* Addison-Wesley. 1992.
8. Aris, R. *Vectors, Tensors and the Basic Equations of Fluid Mechanics.* Dover. 1962.

ENG(CMMACS)-2-421: High Performance Scientific Computing: 2-1-0-3

Course Coordinator : G K Patra

Modern computer architectures, Programming and Tuning Software, Shared-Memory Parallel Processors, Scalable Parallel Processing, Scientific data formats, **Open source application software**

Basic concepts in parallel computing, parallel algorithms, Introduction to message passing and MPI programming, embarrassingly parallel problems, Problem decomposition, graph partitioning, and load balancing, introduction to shared memory and OpenMP programming techniques, parallel direct and iterative methods, programming on different parallel architectures, applications relevant fields, Debuggers

HPC best practices, Linux shell programming, sequential programming, compiler optimization, Multi-processor parallel programming, benchmarking and performance evaluation on different architecture, Visualization of different data formats.

Recommended Books

1. *High Performance Computing*, Kevin Dowd, O'Reilly Series, 1993.
2. Introduction to High-Performance Scientific Computing ©2010 (Victor Eijkhout)
3. High Performance Computing For Dummies, Douglas Eadline, Wiley Publishing, Inc.
4. High Performance Computing: Paradigm and Infrastructure, L. Yang and M. Guo, ohn Wiley.
5. Designing and Building Parallel Programs, Ian Foster, Addison Wesley, 1995
6. MPI: The Complete Reference**,** Marc Snir, Steve Otto, Steven Huss-Lederman, David Walker, Jack Dongarra, The MIT press, 1996
7. How to write Parallel Programs, A first Course, By Nicholas Carriero and David Gelernter, The MIT press, 1992

ENG(CMMACS)-2-422: Nonlinear Dynamics: 2-1-0-3
Course Coordinator : T R Ramamohan

Introduction/Phase Space, Plane and Portraits : Linear Systems and their classification;Existence and uniqueness of solutions; Fixed points and linearization; Stablility of equilibria; Pendulum Oscillator,Dufing oscillator,Lindstedt`s method; Conservative and reversible systems.
Limit cycles: The Van der Pol oscillator, Method of averaging; Relaxation oscillators; Weakly Nonlinear Oscillators; Forced Duffing oscillator, method of multiple scales; Forced Van der Pol oscillator,entrainment, Mathieu`s equation, Floquet Theory, Harmonic Balance.
Bifurcations: Saddle-node,transcritical,and pitchfork bifurcations; Center manifold theory; Hopf bifurcation; Global bifurcations; and Poincare maps.
Chaotic Dynamics : Lorentz equations; Lorentz map ; Logistic map; Lyanpunov Exponents; Fractal sets and their dimensions; Box ,point wise and correlation dimensions; Strange attractors; Forced two-well oscillators
Time Series Analysis: State space approach

Recommended Books

1. Julien C.Sprott , “Chaos and Time-series Analysis”, Oxford University Press 2003;
2. Mark Shelhamer, “Nonlinear Dynamics in Physiology: a State Space Approach”, World Scientific, 2007
3. Edward Ott, “Chaos in Dynamical Systems”, Cambridge University Press, 1993
4. K.T.Alligood, T.D.Sauer, and J.A.Yorke, “CHAOS-An introduction to Dynamical Systems”, Springer, 1996
5. Steven H. Strogatz, “Nonlinear Dynamics and Chaos” Indian edition published by Levant books, 2007

ENG(CMMACS)-2-423: Applied Computational Methods: 2-1-0-3

Course Coordinator : V Senthilkumar

Ordinary Differential Equations:
Initial Value Problems: Single step methods, Multi step methods
Boundary Value Problems: Shooting Method, Finite Difference Methods, Finite Element Method

Partial Differential Equations:
Finite Difference Discretization, Finite difference treatment of 2nd order nonlinear PDE of parabolic, elliptic types, Hyperbolic problems

Higher Order Methods: Spectral Method, Pesudospectral Method

Recommended Books:

- Numerical Methods for Scientific and Engineering Computation– M.K.Jain, S.R.K.Iyengar and R.K.Jain, New Age International Publishers
- Computational Methods for Partial Differential Equations– M.K.Jain, S.R.K.Iyengar and R.K.Jain, New Age International Publishers
- Numerical Methods for Engineers and Scientists- Joe D. Hoffman, McGraw-Hill, Inc

ENG(CMMACS): 2-424: Numerical Analysis and Fortran Programming: 3-0-0-3

Course Coordinator : P S Swathi

This is a programming-intensive course which will make the students write Fortran codes for numerical analysis topics. There is no separate lab component. Programming assignments will be integral to the course and not considered as lab assignments.
The topics covered will include: Basics of computer floating point arithmetic, Fortran programming and debugging, Taylor series, solution of algebraic equation, linear systems – direct and iterative methods, eigen value problems, least squares and singular value decomposition, interpolation and extrapolation, numerical differentiation and integration, numerical solution of ordinary differential equations

ENG(CMMACS)- 3-001: Advanced Self Study:0-2-4-4

Aims to train the student on learning, on one's own, topics that are not formally taught in a course. This would involve primarily three components - collection of relevant literature on a chosen topic, organization of relevant material into a written report based on candidate's own critical understanding and finally presentation of the findings in front of wide audience in the form of a seminar. Thus communication skills are also expected to be honed up (4 credits)
Course Coordinator: PhD Guide

ENG(CMMACS)-4-001: CSIR-800 Societal Programme: 0-0-8-4

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).
Course Coordinator: Dr P Goswami / Dr Ehrlich Desa

ENG(CMMACS)-4-002: Project proposal writing: 0-1-6-4

Two subject proposals to be prepared before comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc. (2 credits each)
Course Coordinator: PhD Guide

CSIR-CSIO

PHY/ENG(CSIO)-1-001:1-1-0-2: Research Methodology

Course Coordinator: Dr HK Sardana
Introduction to Research: Importance, study of literature, defining research problem, hypothesis formulation, experimental design
Data Collection and Measurement: Methods and techniques, probability and probability distributions, sampling and sampling designs
Data Analysis: Testing of hypothesis, statistical tests and analysis, data interpretation, multivariate analysis, model building, forecasting methods
Report writing and Presentation: Ethics in research, Plagiarism, substance of reports, formats, referencing, oral presentation skills
General practices followed in Research – literature and data management, Safety practices in the laboratory, Intellectual property rights (IPR).

PHY/ENG(CSIO)-1-311:3-1-0-3: Mathematics for Engineers and Scientists

Course Coordinator: Dr GS Singh
Calculus: Differential Calculus, Partial differentiation, Integral Calculus, Multiple integrals, Vector Calculus
Complex Analysis: Complex numbers and functions, Matrices, Calculus of Complex Functions.
Differential Equations: Differential equations of first order, linear differential equations, Differential equations of different type, series solution of differential equations and special functions, partial differential equations.
Series & Transforms: Series, transforms, and complex transforms.

PHY/ENG(CSIO)-3-001:0-2-4-4: Advanced Self Study

Course Coordinator: *PhD Guide*
The main focus of this course is to encourage self-learning in the niche areas of the candidate's interest. The candidate is expected to do an extensive literature survey in the chosen research area and submit an written report of the work and present the work to group of experts in the form of a seminar.

PHY/ENG(CSIO)-4-001:0-1-6-4: Project proposal writing

Course Coordinator: Dr Pawan Kapur
Two subject proposals to be prepared before comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc. (2 credits each)

PHY/ENG(CSIO)-4-002:0-0-8-4: CSIR-800 Societal Programme

Course Coordinator: Dr Pawan Kapur
The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million

Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

ENG(CSIO)-1-486:3-1-0-3: Circuit Theory and Electronic Devices

Course Coordinator: **Dr Pawan Kapur**

Electric circuits and components: Introduction, basic electrical elements – resistor, capacitor, inductor, Kirchhoff's laws, voltage and current sources and meters, network theorems, AC/DC circuit analysis, transformer, impedance matching, grounding and electrical interference.

Semiconductor electronics: Junction diode, Zener diode, analysis of diode circuit, three terminal devices - BJT, JFET, MOSFET, four terminal devices, SCR, DIAC,TRIAC, photo devices - photo diodes, photo transistors, LED, LCD, opto-isolator and opto-couplers, amplifiers: BJT, FET amplifier, single stage, multistage power amplifiers – class A, B, C and D amplifiers, operational amplifiers: specifications, characteristics and applications.

Introduction to computing: Number system and code conversion, logic gates, Boolean algebra, combinational logic circuits, sequential logic circuits – latch, RS, JK, T, D flip flops, shift registers, counters, digital building blocks: decoder, encoder, MUX, DMUX, A/D, D/A converters, memories, programmable logic devices, microprocessors, microcontrollers, Display devices.

Power devices: Construction, rating, characteristics and applications of SCR, TRIAC, IGBT.

ENG(CSIO)-1-487:3-1-0-3:Mechanisms, Materials and Manufacturing

Course Coordinator: **AD Kaul**

Mechanical systems: Types of motion, kinematic chains, freedom and constraints, slider-crank mechanisms, machine elements.

Materials and Processing: Engineering materials, machining processes: conventional, special purpose machines

Measurements & Instruments: Mechanical engineering measurements & instruments: linear, angular, and surface measurements, force, temperature.

ENG(CSIO)-2-486:3-1-0-3: Signal Processing

Course Coordinator: **Dr Amod Kumar**

Signals and Systems, Continuous time signals, sampling theorem, discrete time signals and systems, classification

Transforms, Analysis and Filters, Analysis of linear systems, correlation of discrete time signals, frequency domain analysis, DFT, FFT, z-transform, IIR/FIR digital filter design, basics of DSP processors

Signal processing in instrumentation, case studies.

ENG(CSIO)-2-487:3-1-0-3: Computer Aided Design and Simulation

Course Coordinator: **AD Kaul**

Introduction to Optical Design: Paraxial Optics, Geometrical Optics, Wave Optics, Finite ray tracing, Merit Function and its General Features, Numerical Minimization Methods of Merit Function, Minimization Subject to Constraints.

Design of Popular Optical Systems: Telescopes: Refractive & Reflecting, CCD Camera Optics, HUD Optics

Computer Aided Design for PCB layout: Analog, Digital & Mixed signals, Ground and Power Supply requirements; Active and Passive components behaviour; mixed signal simulation.
System Ruggedisation Fundamentals: Environmental Parameters, Thermal analysis and EMI Fundamentals.
Introduction to CAD/CAE/Simulation: Hardware and Software in CAD/CAE applications; graphics input and output devices; Introduction to 2D, 3D drawings and projections.
Modelling approaches: Geometric modelling, Wire frame modelling, Part modelling, Assembly modelling, Sheet metal modelling, Rendering and Visualisation.
Introduction to Finite Element Analysis: Static, Frequency & Thermal Analysis

ENG(CSIO)-2-488: 3-0-0-3: Human Physiology

Course Coordinator: **Dr Viren Sardana**

Cell and Tissue: Introduction to cell, multicellular organization, basic structure and organization of cell, cell organelles, tissue structure, types of tissue.
Cardiovascular system: Anatomy of cardiovascular system, cardiac muscle, electrical conduction in heart, brief introduction to ECG/EKG, types of circulation, working of heart and cardiac cycle.
Respiratory system: Anatomy of respiratory system, gas exchange, physiology of respiration, spirometry, respiratory volumes and capacities.
Digestive system: Anatomy of digestive system, process of digestion, absorption and excretion, role of digestive enzymes and juices, hepatobiliary system.
Nervous and endocrine system: Anatomy of nervous system and endocrine system, action potential, division of nervous system, nerve tissue, transmission across synapse, reflexes, neural control of different major body stems, sleep cycle, special senses (eye, ear, smell), role of hypothalamus, pituitary, different hormones and their role.
Musculoskeletal system: Types of muscles, muscle contraction physiology, types of bones, bone macro and micro anatomy, bones in body, cartilage types, joints types, movement at joints, fracture types and healing.
Urinary system: Anatomy of renal system, working of the kidneys, process of urine concentration and bladder control, maintenance of acid-base balance.
Immune system: Immunity, Types of immunity, components of Immune system, antibodies, antigen, blood groups, detection of antigen/antibody as basis of disease diagnostics.

ENG(CSIO)-3-486:3-0-2-4: Digital Image Processing

Course Coordinator: **Dr HK Sardana**

Introduction: Elements of visual perceptions, digital Image sensing, sampling and quantization, digital image representation, basic relationship between pixels, elements of digital image processing system.
Image transforms: Discrete Fourier transform and properties, separable image transforms, image enhancement. Wavelet transforms.
Restoration and Reconstruction: Image restoration, image segmentation, image reconstruction from projections.
Statistical pattern recognition: Cluster analysis, feature selection & extraction, syntactic pattern recognition: stochastic languages, problem solving methods for pattern recognition.
Case studies: Medical image processing, colour image processing, thermal image processing.

ENG(CSIO)-3-487:3-0-2-4: Statistical Analysis & Machine Intelligence

Course Coordinator: **Dr HK Sardana**

Statistical Analysis: Statistics In Research, Common Terms in Statistics, Constraints in Research, Population and Sample, Choosing Appropriate Sample Size, Sampling, Errors in Sampling, Data Collection, Bias in Statistics, Data representation, Types of Data, Data Analysis, Measures of Central Tendency, Standard deviation, Variance, Standard Error of Means, Gaussian Distribution, Normal Distribution Curve, Skewness, Tests of Significance – t/z/ANOVA, chi square test, correlation and regression analysis.

Applied Machine Learning: Linear algebra revisited, ML Tools, Introduction to Machine Learning –Supervised Vs. Unsupervised Learning, Linear regression, Logistic regression, Regularization, Neural networks- Representation and Learning, Machine Learning System Design, Support Vector Machines, Clustering, Dimensionality reduction, Anomaly detection, Recommender systems, Large scale machine learning, Applications- enose, iTongue, cancer, Iris, Boston housing, sonar, wine etc .

Hybrid systems: Uncertainty and imprecision, fuzzy systems, linguistic rules, approximate reasons, neuro-fuzzy systems, genetic algorithms and evolving neural networks, applications in control, inspection, monitoring, forecasting, recognition and diagnosis, Applications/Case Studies: Engineering design optimisation, optimiser behaviour evaluation through stochastic analysis, performance analysis, optical design and engineering, mechatronic products, agro applications.

ENG(CSIO)-3-488:3-0-2-4:Biological Control Systems

Course Coordinator: **Dr Pawan Kapur**

Introduction: Control systems, transfer functions, mathematical approaches, system stability, feedback concept and stability analysis, Biological control system, comparison with engineering control, transfer of various bio-chemicals between compartments, biological receptors and actuators, characteristics, transfer function model, bio-feedback mechanism.

Regulation: Regulation of acid-base balance, regulation of extra cellular water and electrolytes, process controls-cardiac rate, blood pressure, respiratory rate and blood glucose regulation. Endocrine control, Pharmaco modelling-drug distribution system, regulation of interstitial fluid volume. CO_2 regulations.

Modelling of Human Systems: Modelling of human cardiovascular system, respiratory system, thermal regulatory system, etc, parameters involved, control system models etc, heat loss from the body, model of heat transfer between subsystems of human body like skin, core, body in relation to environment.

Bio-mechanics: Muscle behaviour to excitation & EMG analysis, stiff leg gait model, Gait pattern in terms of step size, Step frequency, Comfortable walking & gait behaviour during exercise. Heat-lung information pathways under normal and exercise conditions in terms of O_2 and CO_2 balance.

Hearing and Vision System: Information pathways for various sensory organs such as hearing, vision, smell, etc. Skull position & velocity sensing, auditory cupila dynamics, time & frequency response characteristics, papillary dynamics for optimum flux density as retina, cilliary muscles control, transient response, eye tracking problem and various information pathways, etc.

ENG(CSIO)-3-489:3-0-2-4: Bio Instrumentation

Course Coordinator: **Dr Amod Kumar**

Introduction - Cellular organization: Cell, Action potential of cell, Transport of substances across biological membrane.

Cardiovascular system: heart, arterial and venous system, blood, cardiac cycle. Basics of ECG, PCG. Measurement of blood pressure by direct and indirect methods. Plethysmography.

Defibrillators: DC defibrillators, AC defibrillators of capacitance discharge and delay line capacitance discharge with basic circuit diagrams. Types of electrodes and their features.

Cardiac pacemakers: Asynchronous and Synchronous (demand) Mode of operation. External and

Implantable Asynchronous pace makers. Working Principles, modes of triggering.

Respiratory system: Trachea and Lungs. Respiratory Physiology. Spirometry, Ventilators.

Nervous system and special senses: Nerve physiology. Basics of EEG. Electrodes used for measurement of EEG.

Skeletal system: Classification of Bones, Joints and Muscles- Structure and function. Basics of EMG.

Bipotential Electrodes: Electrode electrolyte interface, half cell potential polarization , electrode skin interface and motion artefact. Types of electrodes. Micro electrodes.

Miscellaneous: Hearing aids, Heamodialysers- types of exchangers. Lasers in Surgery, Principles and applications of Endoscopes.

Electrical hazards in hospitals: Patient electrical safety, types of hazards, patient isolation, physical effects of current, let – go – current, Micro shocks, different ways for electrical accident to

occur, safety instruction circuits, electrical grounding & effects.

ENG(CSIO)-3-490:3-0-2-4: Agri-Physics and Agro Control Systems

Course Coordinator: **Dr Pawan Kapur**

Measurement techniques and instruments for various agri-parameters such as pH, electrical conductivity, moisture content, temperature, relative humidity, viscosity/ consistency, rheology, heat transfer coefficient, visco-elastic behaviour, etc.

Modelling of key agri-processes such as material carrier, extraction, clarification, concentration, crystallisation, drying etc. Typical case studies of level control, consistency control, bio-chemical reactions based on material balance, heat balance, population balance, etc.

Instrumentation & control for various unit processes such as precision farming, cultivation under controlled atmosphere, photosynthesis, crop health monitoring, pesticide estimation, soil mapping, light flux density, etc.

Case studies of some key agro-based industries in terms of instrumentation & control : automatic grading & sorting of fruits / vegetables, controlled environment storage system (seed potatoes), Juice clarification, evaporation and crystallisation process in cane sugar industry, instrumentation in tea processing such as withering, rolling/CTC, fermentation, drying, etc. Mushroom cultivation in environmentally controlled cropping houses, control system realisation, algorithm development (PID, PD_2T_2), tuning of controller, performance evaluation, identification techniques.

ENG(CSIO)-3-491:3-0-2-4: Agro Mechanical Systems

Course Coordinator: **VPS Kalsi**

Agriculture Parametric Study: Field measurements, Soil dynamics & water resources, Agriculture field engineering, Pre & Post harvesting
Agriculture Engineering: Elements of machine design, Computer aided design, simulation & analysis, instrumentation & process control
Farm Machinery: Tractor system & control, Production technology for agriculture machinery, Tractor mounted gadgets for pre & post harvesting, Resources of Irrigation, Conveyor systems, Grading & Sorting of fruits & vegetables, Storage chambers, Chilling, Humidification & Aeration units, Processing system (solar drying, juice extraction , clarification , filtration), Control valves & actuators, Material characterization
Agriculture Economics: Agro environmental science, Principle of ergonomics & safety, Human engineering & safety, Precision farming & natural resource farming

ENG(CSIO)-3-492:3-0-2-4: Optical Instrumentation
Course Coordinator: **Dr GS Singh**
Geometrical Optics: Optical Components: Lenses, Mirrors, Prisms; Diffraction Gratings, Optical System Layout, Basics of Lens Design, Zoom Lenses, Mirror and Catadioptric Systems, Optical Specifications and Tolerances

Physical Optics: Apertures and Diffraction, Wave Aberrations and MTF, Fourier Optics & Optical Signal Processing; Diffractive Optics, Quantum Optics

Optical Materials & Coatings: Optical Glass, Plastics, IR Materials, Anti Reflection Coatings, Reflection Coatings, Interference Filters

Radiometry and Photometry: The Inverse Square Law; Intensity; Radiance and Lambert's Law; the Radiometry of Images, Blackbody Radiation, Photometry, Illumination Devices

ENG(CSIO)-3-493:3-0-2-4: Opto-Mechanical Systems
Course Coordinator: **Dr SV Ramagopal**
Module – i: Optical fabrication & metrology
Optical materials, optical shop supplies, tools & fixtures, optical processors, optical processing, optical shop testing.
Module – ii : Opto-mechanics: design, fabrication & metrology
Opto-mechanical design process, environmental influences, mounting individual lenses, mounting multiple lenses.
Module –iii : Display technology
Principles, Emergent Technologies, Application Areas for Display Devices Including CRT, LCDs, Reflective Displays, Emissive Devices (OLEDs), Plasma Displays, Scanned Laser Displays, Digital Micro-mirror Devices. Fundamentals of Light & Vision, Display Electronics & Calibration; Display Measurement: Concepts, Techniques, And Instrumentation; Commercial, Industrial & Military Standards For Testing of SW & HW; Environmental & Performance Testing Parameters & Standards For Display Systems

CSIR-CIMFR

ENG(CIMFR):1-002	MATHEMATICS FOR ENGINEERS	L-T-P-C:3-0-0-3
Course Coordinators: Dr. Ajay Kumar Singh and Dr. M. Sundararajan		
Linear Algebra: Linear independence; Orthogonality; Vector Spaces and their bases and dimensions; Gram-Schmidt method for orthogonal basis set; Orthogonal projections; Matrices; Solution methods for linear simultaneous equations; Eigenvalue problem. Vector Analysis: Vector differentiation, Applications; Vector operators: Grad, Div and Curl. Vector integration and related Integral Theorems, Applications; Cylindrical and Spherical Co-ordinate Systems. Differential Equations: Linear ODEs of first and second orders; Linear second order equations, Applications; The Laplace Transform, Applications; Fourier Series and Applications; Partial differential equations of first and second orders; The Laplace and Wave Equations.		
ENG(CIMFR):1-311	**ROCK MECHANICS AND GROUND CONTROL IN MINING**	**L-T-P-C:2-0-2-3**
Course Coordinators: Dr. Rajendra Singh and Dr. C. N. Ghosh		
Rocks and rock structures; Rock mass classification; Rock mass properties; Rock failure criteria; Stresses in elastic and plastic ground conditions; Effect of anisotropy and inhomogeneity on rock properties; *In situ* stresses and its measurements; Different types of ground excavations and effects of their instability; Design of roadways and pillars; Approaches of ground behaviour evaluation; Different types of rock reinforcement and support; Ground Control measures during different methods of mining; Rock bursts and bumps; Slope stability evaluation: Discontinuities and geomechanical properties of slope mass; Groundwater condition and its measurement; Mechanics of slope stability; Slope stability in weathered slopes; Case studies.		
ENG(CIMFR):1-312	**ENGINEERING GEOLOGY**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. A. Sinha and Dr. R. K. Goel		
Depositional textures and structures; Physics of deformation with surroundings, time and material; Planar and linear structures; Faults, folds, cleavages, dip, strike, contour, stratification, lamination, bedding; Unconformity & joints - their classification and Recognition in the field; Major structures and tectonics; Structures in igneous rocks and igneous intrusions; Geomorphology and structure morphotectonics; Mineral Exploration: Geological, Geophysical and Geochemical Prospecting; Study of geological structures; Management and utilisation of geological data; Coal geology; Hydrogeology.		
ENG(CIMFR):1-313	**MINE SAFETY LEGISLATIONS AND SAFETY MANAGEMENT**	**L-T-P-C:3-0-0-3**
Course Coordinators: A. K. Ghosh and Dr. S. K. Singh		
Mine Safety Legislations: Mines Act; Mine Rules; Coal Mines Regulations; Metalliferous Mines Regulations; Mines and Minerals (Development and Regulations) Act; Mines Rescue Rules; Circulars; Other related industrial legislations, circulars, documents related to mine safety. Mine Safety Management: Requirements for effective safety management; Mine safety management system –		

background, objectives and structure; Different levels of safety management; Processes of safety management; Hazard identification and risk assessment; Risk management, case studies; Concept of mine safety monitoring. Purpose and classification of safety monitoring. Mine safety monitoring techniques; Preparation of safety monitoring plan; Measurement of safety efficiency; safety audit; safety records.		
ENG(CIMFR):1-314	**ROCK MECHANICS INSTRUMENTATION AND MONITORING**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. P. K. Mandal and D. Kumbhakar		
Ground behaviour and instability in ground excavations; Methods of studying ground behaviours; Monitoring of ground behaviour in underground mines; Different types of field instruments used for rock mechanics instrumentation and monitoring – sensors and transducers, readout units, data acquisition systems, etc.; Rock mechanics testing equipment; Acoustic emission equipment; Monitoring of reinforcement and support system; Rock bolt pull tester; GPR based monitoring of underground structures; Field instrumentation and monitoring of slopes; Conventional and GPS based monitoring; Real-time monitoring; Communications/storage of data; Analysis of data and evaluation of ground stability.		
ENG(CIMFR):1-315	**METHODS OF MINING**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. Arun Kumar Singh and Amar Prakash		
Methods of exploration; Evaluation of mineral deposits; Mine planning; Surface and underground mining; Opening of mineral deposits; Shaft sinking; Methods of excavations; Explosive and Blasting; Conventional and special methods of mining; Mining Machinery and its applications.		
ENG(CIMFR):1-316	**ROCK EXCAVATION ENGINEERING**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. C. Swamliana and N. Kumar		
Rock Excavation by drilling and blasting; Study of the theories of rock penetration including percussion, rotary, and rotary percussion drilling; Rock fragmentation including explosives and the theories of blasting rock; Application of theory to drilling and blasting practice at mines, pits, and quarries; Mechanised Excavation of Rock; Classification and construction of extraction machineries; Different types of machineries and their suitability; Selection of equipments and machineries; Operational conditions; Safety measures; Performance monitoring; Condition monitoring and maintenance; Study of excavation stability; Excavation support design.		
ENG(CIMFR):1-317	**RELIABILITY AND MAINTENANCE ENGINEERING IN MINING SYSTEMS**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. D. Basak and Dr. Ranjan Kumar		
Statistical methods in reliability: Basic statistics and probability theory; Reliability concepts: Reliability function, failure rate, MTTF, MTTR, mortality curve, useful life, availability, maintainability, system effectiveness; Reliability analysis and prediction: Time to failure distribution, exponential, normal, gamma, weibull distribution, system reliability evaluation, standby systems; Design for reliability: Design theory, design for reliability, design for maintainability, reliability improvement techniques; Maintenance engineering: Introduction, maintenance policies, failure, diagnosis, Markov maintenance, process maintenance support and logistics, maintenance management; Reliability and maintenance in mining: Failures in mining systems, reliability testing, machine maintenance management, human reliability, mine systems reliability improvement, reliability optimization.		
ENG(CIMFR):1-	**ENVIRONMENTAL MANAGEMENT IN MINING INDUSTRY**	**L-T-P-C:3-0-0-**

318		**3**
Course Coordinators: Dr. (Mrs.) B. Prasad and Dr. R. Ebhin Masto		
Concept of sustainable and eco-friendly mining; Impacts of mineral exploration, mining, processing and utilization on environment; Air quality standards, air pollutant sources and health effects; Source and occurrence of waters in mines; Mine water contaminants and their natural attenuation; Acid mine drainage and mine water treatment; Soil conservation and erosion control, restoration of soils, Importance, threats, approaches for conservation and management of biodiversity; Methods of collection and analyses of water, soil, gaseous and particulate pollutants; Bio-monitoring and analytical techniques; EIA/EMP, Environmental clearance; Environmental Law, Legislation and Policies; Principles of mine closure plan; Environmental Hazard and Risk Assessment.		
ENG(CIMFR):2-311	**NUMERICAL SIMULATION AND STABILITY EVALUATION OF MINING STRUCTURES**	**L-T-P-C:2-0-2-3**
Course Coordinators: Dr. G. Banerjee and Dr. P. K. Mandal		
Different numerical methods; Inputs of numerical methods; Model generation; Application of Finite difference method; Finite element method; Distinct element method; Boundary elements method; Hybrid methods; Application of different numerical modelling methods and software for ground stability evaluation of mining structures; Validation of models; Design optimisation through numerical modelling; Case studies.		
ENG(CIMFR):2-312	**ADVANCED MINE VENTILATION AND ENVIRONMENT**	**L-T-P-C:2-0-2-3**
Course Coordinators: Dr. N. Sahay and Dr. J. K. Pandey		
Mine Ventilation systems; Mine thermodynamics and computation of psychometric properties; Modes of heat transfer; Designing of climatic conditions in panels; Computation of volume flow; Application of Kirchoff's second law to solve field problems; Hardy Cross Iterative method and its application to solve ventilation network problems; Thermodynamic principles applied to ventilation network analysis; Air Leakage; Recirculation and reversal of air flow; Pressure behavior of sealed-off area; Dynamic balancing of pressure technique; Ventilation survey and planning; Air conditioning; Environmental monitoring; Network analysis; Ventilation survey instruments; Simulations of mine ventilation network; Design of coal dust control plan; Noise and Vibrations; Mine Illumination.		
ENG(CIMFR):2-313	**ADVANCED MINE SURVEYING AND SUBSIDENCE ENGINEERING**	**L-T-P-C:2-0-2-3**
Course Coordinators: Dr. K. B. Singh and A. Prakash		
Concepts of Surveying; Automatic Level; Digital Level & Optical Theodolites; Data collection procedures; GIS:GIS Data Models; Data Acquisition; Maps and Map Projections; Surveying using EDM; Total Station and its application in Mine Subsidence and Ground Movement Monitoring of Opencast Mine Slopes; 3D Scanning; 3D Ground/Mine Surface Modelling using Total Station; Section extraction and excavation volume computation in civil and mining application; Mapping. Subsidence: Causes and types of subsidence; Subsidence measurement methodologies and prediction; Environmental impacts of subsidence on land, buildings, ground water, forest cover, etc.; Safe limits of subsidence for different surface features and structures; Subsidence control measures.		
ENG(CIMFR):2-	**MINE FIRE, ACCIDENTS AND DISASTERS - ANALYSIS AND**	**L-T-P-C:3-0-0-**

314	PREVENTION	3
Course Coordinators: Dr. R. V. K. Singh and Dr. I. Ahmad		
Causes and types of mine fire; Fire risk assessment; Detection and Assessment of spontaneous heating/fire; Gas hazards; Methods of sampling of gases from fire area; Mine gas Analysis; Thermo-compositional Investigation; Environmental affects due to fire; Fire prevention and combating; Fire combat methods; Dealing with long standing fires; Fire fighting equipment. Types and Causes of mine accidents; Dangerous occurrences in mines; Study of mine accidents and its analysis; Mine accidents and disasters; Analysis of mine accidents and preventive measures. Types and causes of mine disaster; Mine inundation; Design of underground dams; Mine explosion; Mine rescue; Mine disaster control and mitigation.		
ENG(CIMFR):2-315	**MINE SAFETY EQUIPMENT: DESIGN, TESTING AND EVALUATION**	**L-T-P-C:1-0-2-2**
Course Coordinators: Dr. P. K. Mishra and R. K. Vishwakarma		
Types of mine safety equipment; Safety parameters in mine equipment; Legislations related to safety equipment; Principles of design of safety equipment; Different types of testing procedures; Testing and evaluation of safety equipment, machines, electrical cables, wire ropes and other accessories; Electrical hazards; Flame proof and intrinsically safe electrical equipment.		
ENG(CIMFR):2-316	**ADVANCED MINING METHODS**	**L-T-P-C:3-0-0-3**
Course Coordinators: A. K. Ghosh and D. Kumbhakar		
Design of mine layouts for underground and surface mining; Design of coal and hard rock pillars; Advanced and special mining methods; Review of various experimental mining methods/procedures; Assessment of caving characteristics; performance and application of backfill; Coal bump and rock burst and their alleviation. Thick, thin and complex seams mining; Underground Coal Gasification and Coal Bed Methane; Choice of stoping method; Stope design; Production planning; Special underground excavations in metal mines; Consolidated and unconsolidated hydraulic & dry filling, paste filling stopes, preparation, transportation and filling operation; Solution Mining: in-situ leaching, chemical, bio-chemical and thermal leaching; Novel mining methods.		
ENG(CIMFR):2-317	**MECHANISATION AND AUTOMATION FOR MINE SAFETY**	**L-T-P-C:3-0-0-3**
Course Coordinators: Dr. G. Banerjee and Dr. C. N. Ghosh		
Selection, procurement and replacement of mine equipment; State-of-the-art and future trends in mine mechanization and mine automation systems for both surface and underground mining; infrastructure required to support mine automation; Application of robotics and intelligent systems for safer mining; Potential economic, health and safety benefits of mine mechanisation and automation.		
ENG(CIMFR):2-318	**ROCK BLASTING AND FRAGMENTATION**	**L-T-P-C:3-0-0-3**
Course Coordinator: Dr. P. Pal Roy		
Advanced study of the theories of rock penetration; Explosives: Chemistry and physics of explosives;		

Properties of explosives; Explosive and blasting accessories; Initiation and priming systems; Bulk explosives; Heavy ANFO, ANFO with Sawdust & Rice-Husk; Criteria of explosive selection; Rock breakage by explosives: Theories, Rock breakage mechanism, Methods for prediction and assessment of fragmentation; Design of blasting rounds for surface and underground excavations; Special blasting techniques: Secondary breakage; Pre-split blasting; Smooth blasting; Cast blasting; Segregation blasting; Demolition blasting; Trench blasting and Induced caving by blasting. Environmental considerations: Control of Noise; Ground vibration; Air blast and Fly rock; Dust & Fumes.		
ENG(CIMFR):2-319	**INDUSTRIAL PHYSIOLOGY AND ERGONOMICS**	**L-T-P-C:3-0-0-3**
Course Coordinators: A. K. Ghosh and Dr. Ranjan Kumar		
Anthropometry for design and body composition; Design principles – work station and tool design. Human information processing: man-machine-environment system. Environmental ergonomics and climatic factors: illumination, noise and vibration; Occupational health; Physiological factors. Fatigue-shift works. Control and display. Work posture. Selection of work force and training. Industrial and personal safety.		

CSIR-IICT

PES 611: Numerical methods and Process Modeling : 3 Credits

Fundamentals of mathematical modeling
Chemical Process Modeling
Numerical methods
Process optimization
Process simulation using Software Packages

PES 612: Advanced Separation Processes : 3 Credits

Fundamentals of Separation Processes
Binary Separation Processes
Multi-component Separation Processes
Rate Based Separations
Hybrid Separations
Reactive Separations

PES 613 : Reaction Technology : 3 Credits

Homogeneous reactor design and analysis: Non-ideal reactors
Heterogeneous reactors for fluid-fluid systems: Kinetic evaluation and design
Heterogeneous reactors for fluid-solid systems: Kinetic evaluation and design
Novel Reactor Configurations

PES 711 : Process Engineering : 4 Credits

Process Route Selection
Process Flow sheeting
Process optimization
Process Equipment Design
Advanced Process Engineering Concepts

PES 614 : Advanced Chemical Engineering Thermodynamics : 3 Credits

Basic concepts of thermodynamics
Solution thermodynamics: Properties of mixtures
Phase equilibria: VLE, LLE, VLLE, SLE
Chemical reaction equilibria: Multi-reaction equilibria
Introduction to molecular and statistical thermodynamics

PES 621 : Advanced Process Design : 3 Credits

Heat transfer equipment design
Mass transfer Equipment design
Reactor design
Process Instrumentation
Process Safety and Hazard analysis
Computer Aided Process Design

PES 622 : Advanced Process Optimization : 3 Credits

Unconstrained Optimization – single variable and multivariable
Linear programming
Nonlinear programming with constraints
Mixed Integer Programming
Global optimization
Optimization of heat transfer applications
Optimization of separation processes
Optimization for Chemical Reactor Design and Operation

PES 721 : Process Integration and Intensification : 4 Credits

Introduction to process integration and intensification
Heat Exchange Network Synthesis
Mass Exchange Network Synthesis
Reactor Network Synthesis
Equipment based Process Intensification
Method based Process Intensification

PES 623 : Membrane Technology : 3 Credits

Introduction to membrane separation processes
Membrane transport theories
Membrane preparation techniques
Design and analysis and industrial applications of membrane processes
Membrane reactors and membrane contactors

PES 624 : Advanced Process Monitoring and Control : 3 Credits

Introduction to Advanced control systems
Controllability, Observability and Stability Analysis
State estimation and inferential control
Adaptive Control
Nonlinear Model based Control
Model predictive control with linear, nonlinear and data-driven models
Plant wide control
Fault detection and diagnosis

PES 631: Research Methodology & Technical Communication Skills : 3 Credits

Literature review
Effective scientific writing & presentation
Intellectual property management
Research planning
Effective written and oral communication
Ethical issues

PES 632: Artificial Intelligence in Process Engineering : 3 Credits

Introduction to Artificial Intelligence (AI)
Data reduction and classification methods
Expert systems
Evolutionary optimization methods
Neural Networks - Concepts and Applications

PES 633: Biochemical Engineering : 3 Credits

Introduction to Biochemical Engineering
Fermentation processes – microbial & enzymatic
Bioprocess Modeling
Bioreactor design
Downstream processing operations

CSIR-IIP

Course No: ENG(IIP): 3-610
L-T-P-C: 3-0-0-3
Course Title: Advanced Thermodynamics for Mechanical Engineers – 3 Credits
Coordinating Faculty: Dr. Jasvinder Singh
List of Faculty: Dr. Jasvinder Singh, Dr. S K Singhal, Sh. A K Jain, Dr. M. O. Garg

Course Description

Basic concepts

P-V-T behavior of pure liquids; Application of thermodynamic Laws to real processes. Applications of equations of state; thermodynamic property calculations for fluid mixtures, Gibb's & Helmholtz functions. Available & non-available energy, Irreversability

Thermodynamics of flow systems

Fundamental flow equation, Flow meters, thermodynamic analysis of flows in pipes, nozzles, and compressors, fluid temperature change and its measurement at high velocities.

Heat Engines & Chemical Kinetics

Thermodynamic Relationships, Clausius-Clapeyron Equation; Liquefaction of Gases, The Joule-Thomson Effect, Inversion Point on *p-v-T* Surface for Water; Rankine Cycle, Efficiency of an Internally Reversible Heat Engine; Chemical Kinetics: Reaction Rates, Rate Constant for Reaction, *k*, Chemical Kinetics of NO, The Effect of Pollutants formed through Chemical Kinetics

Thermodynamics of Combustion

Combustion of Hydrocarbon Fuels, Energy Equations, Chemistry of Combustion, Bond Energies and Heats of Formation, Enthalpy of Reaction, Chemical Equilibrium and Dissociation, Gibbs Energy, Stoichiometry, Van't Hoff Relationship, Dissociation Calculations, Effect of Dissociation & Fuel on Composition of Products, Combustion and Flames: Explosion Limits, Flames, Flammability Limits, Ignition, Diffusion Flames, Engine Combustion Systems

Irreversible Thermodynamics & Fuel Cells

Introduction, Definition of Irreversible or Steady State Thermodynamics, Entropy Flow and Entropy Production, Thermodynamic Forces and Thermodynamic Velocities, Onsager's Reciprocal Relation, The Calculation of Entropy Production or Entropy Flow, Thermoelectricity, Electric Cells, Fuel Cells, Efficiency of a Fuel Cell, Thermodynamics of Cells Working in Steady State, Diffusion and Heat Transfer

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr. Jasvinder Singh	Sr. Technical officer (3)	20
Dr S K Singhal/ Sh A K Jain	Chief Scientist	16
Dr. M. O. Garg	Director	4

Course No: ENG(IIP): 2-611
L-T-P-C: 3-0-0-3
Course Title: Internal Combustion Engines – 3 Credits
Coordinating Faculty: Dr. S. K. Singal
List of Faculty: Dr. S. K. Singal, Sh. A. K. Jain, Sh. Sunil Kumar Pathak, Sh. Devendra Singh, Dr. B. P. Pundir (External).

Course Description

Classification of Engines; Four and Two Stroke Engines, Auto and Diesel Cycles. SI Engines: Basic layout, Combustion characteristics, Ignition limits, P-Ɵ diagram. CI Engines: Ignition delay, Combustion characteristics, Pre-mixed and diffusion combustion, P- Ɵ diagram.

Injection Systems: In-line injection system, Rotary and unit injector.

Induction and Exhaust Systems: Induction and Exhaust Manifold configuration.

Valves and Camshaft: Valve timing diagrams, operating conditions, valve overlap, cam design.

Super charging and turbo charging: Super charging cycle, gas exhaust process.

Simulation and modelling of IC engines.

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr. S. K. Singal	Chief Scientist	10
Sh. A. K. Jain	Chief Scientist	10
Sh. Sunil Kumar Pathak	Sr. Scientist	5
Sh. Devendra Singh	Scientist	5
Dr. B. P. Pundir	Ex. Prof. IIT Kanpur (External)	10

Course No: ENG(IIP): 2- 593
L-T-P-C: 2-0-4-4
Course Title: Analytical Methods used in Petroleum Industry – 4 Credits
Coordinating Faculty: Dr. Y. K. Sharma
List of Faculty: Dr. S. S. Ray, Sh. A. Majhi, Sh. Pankaj Kumar Kanojia, Dr. R. C. Chauhan, Sh. Sarabhjeet Singh.

Course Description

Standard procedures: Principles, procedures and significance of ASTM/IP/UOP/IS test methods for evaluation and analysis of crude oil and its products; Atmospheric distillation (ASTM D 86); Vacuum distillation; Simulated distillation; True Boiling Point (TBP) distillation; Separation Methods: Chromatography; Gas Chromatography; Liquid Chromatography and Super Fluid Critical Chromatography (SFC); Spectroscopic techniques: Applications of ultra violet spectroscopy (UV); flourier transform infrared (FTIR); Nuclear Magnetic resonance (NMR) spectroscopy and Mass spectroscopy to petroleum products analysis; Elemental analysis: C, H, O, N and S; Metal analysis: Microanalysis; Xray fluorescence; plasma spectroscopy and atomic absorption spectroscopy; All the methods will be complemented with practical work in Laboratories.

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr. Y. K. Sharma	Senior Principal Scientist	10
Dr. S. S. Ray	Senior Principal Scientist	10
Sh. Pankaj Kumar Kanojia	Scientist	9
Dr. R. K. Chauhan	Sr. Technical officer (3)	5
Sh. Sarabhjeet Singh	Sr. Technical officer (3)	3
Dr. A. Majhi	Scientist	3

Course No: ENG(IIP): 2- 612
L-T-P-C: 3-0-0-3
Course Title: Tribology and Tribo – Component Design – 3 Credits
Coordinating Faculty: Sh. G. D. Thakre
List of Faculty: Sh. G. D. Thakre, Sh. B. M. Shukla.

Course Description

Introduction to Tribology: Friction and Wear; Surface phenomena, nature of surface and contact, surface interaction and friction. Effect of lubricants and surface films. Theory of friction. Mechanism of wear, types of wear – adhesive, abrasive, fatigue, corrosive etc. with reference to machine elements and subcomponents like bearings, clutches, brakes etc. Minimization of wear. Wear tests and testing machines. Basic principles of lubrication, lubrication theories; Hydrostatic, boundary, hydrodynamic and elasto-hydrodynamic lubrication. Generalized Reynolds equation, flow and shear stress. Lubricants: types and properties. Effective machinery lubrication, Machine fault detection through lubricant analysis. Laboratory practical on Tribology.

Tribo-component design: Tribologically relevant properties of materials, friction materials and their application in clutch and brake linings. Antifriction/plain bearing materials, wear resistant materials. Surface modification techniques. Materials for specific applications eg. Gears, Seals, hydraulic components etc. Design, application and selection of various types of bearings – sliding and rolling element bearings. Mechanism of hydrodynamic instability. Dynamic characteristics of hydrodynamic journal bearings. Concept of air and magnetic bearings. Design and performance evaluation of Engine components, clutches, brakes seals etc. Application of soft computing techniques. Mini project/seminar on design and simulation.

- **Distribution of Lectures**

Name	**Designation**	**No. of Lectures**
Sh. G. D. Thakre	Scientist	30
Sh. B. M. Shukla	Chief Scientist	10

Course No: ENG(IIP): 2- 613
L-T-P-C: 3-0-0-3
Course Title: Chemistry of Lubricants – 3 Credits
Coordinating Faculty: Dr. O. P, Khatri
List of Faculty: Dr. O. P. Khatri, Dr. R. K. Singh.

Course Description

Introduction to Lubrication: Fundamentals, Boundary Lubrication phenomena, Lubricants, Types of Lubricants, Base Oils from Petroleum, Bio-lubricants, Synthetic Oils, Ionic Liquids, Solid Lubricants, Lubricant Additives, Antioxidants, Dispersants, Detergents, Rust and Corrosion Inhibitors, Foam Inhibitors, Pour Point Depressants, Anti-Wear Agents and Extreme Pressure Additives, Multi-functional Additives, Formulation of Automotive Lubricants, Automotive Lubricant Specifications, Standard Tests for Lubricants, Lubricant and Environment.

- **Distribution of Lectures**

Name	**Designation**	**No. of Lectures**
Dr. O. P. Khatri	Senior Scientist	20
Dr. A. K. Chatterjee	Chief Scientist	5
Dr. S. L. Jain	Senior Scientist	3
Dr. R.K. Singh	Junior Scientist	8
Sh. O.P. Sharma (Lab.)	Technical Assistant	5

Course No: ENG(IIP): 3- 614
L-T-P-C: 3-0-0-3
Course Title: Automotive Lubricants – 3 Credits
Coordinating Faculty: Sh. Devendra Singh
List of Faculty: Sh. Nishan Singh, Dr. A. K. Chaterjee, Dr. Manoj Srivastava, Sh. G. D. Thakre, Sh. S. K. Chibber (External)

Course Description

Introduction and Fundamentals of Automotive lubricants; Crude oil Scenario; Vacuum Distillation; Modern refining process; Base oils classifications; characterization of Base oils; Additive types and Significance; Lubricant formulations; Additives for bio-lubricants; Novel additives

Introduction to fluid dynamics; Lubrication fundamentals; Characteristics of principal lubrication system; Basics of engine friction; Stribeck curve; Engine friction measurement methods; Application of Reynolds equation for Piston ring assembly friction (PRA); Significance of engine oil consumption; Mechanism of oil consumption; Influence of engine lubricant composition on Oil consumption; Influence of engines on Oil consumption; Types of engine deposits based on temperature; Significance and methodology of Deposit Rating; Rating of engine deposits as per CRC methods

Tribological concepts of engine wear; Adhesive, Corrosive and Abrasive wear of Ring/cylinder/Piston; Running-in; Significance of wear metal analysis; Engine lubricant additives requirement

Physico-chemical characteristics of engine lubricants; Engine lubricant qualification methodology; Engine Oil Specification (API/ ILSAC/ ACEA/ BIS) and Current performance levels; Engine lubricant's composition effect on emissions & fuel economy;

Introduction to Gears lubricants and greases; Additives requirements for Gear lubricants; Gear Lubricants and Greases additive chemistry, formulations & significance; Gear lubricant specifications and Gear lubricant testing (Standard tests); Grease specifications and current trends; Wear mechanism in gear; Gear distress rating as per CRC

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Sh. Devendra Singh	Scientist	15
Sh. Nishan Singh	Chief Scientist	6
Sh. S. K. Chibber	External	5
Dr. A. K. Chaterjee	Chief Scientist	4
Dr. Manoj Srivastava	Principal Scientist	5
Sh. G. D. Thakre	Scientist	5

Course No: ENG(IIP): 3- 615
L-T-P-C: 3-0-0-3
Course Title: Automotive Emissions & Fuel Quality – 3 Credits
Coordinating Faculty: Sh. A. K. Jain
List of Faculty: Sh. A. K. Jain, Dr. S. K. Singal, Sh. Sunil Kumar Pathak, Dr. B. P. Pundir (External).

Course Description

Automotive Emissions:

Automotive engine types, combustion processes and exhaust emissions from S.I. and C.I. engines, sources of engine/vehicle emissions, emissions and pollutants, photochemical smog, emission formation in SI and CI engines, mechanisms of NOx formation, mechanisms of CO and HC formation, mechanisms of formation of soot and PM, effect of engine design and operating variables on emissions, emission control by engine design variables, crankcase emission control, evaporative emission control, exhaust gas recirculation and water injection for control of engine-out emissions, SI engine exhaust after treatment by oxidation and three-way catalytic converters, advanced catalysts for HC control, lean de-NOx catalysts, NOx storage catalyst, SCR catalysts, catalyst deactivation and poisoning, emission control in CI engines including electronic fuel injection systems, turbo charging, control of oil consumption, diesel oxidation catalysts, NSR and SCR catalyst systems, diesel particulate filters, CRT system, emission norms for various categories of vehicles, summary of trends in emission control technology, air pollution due to automotive exhaust, consequences of greenhouse effect and ozone problem, health impacts of air pollution

Automotive Fuel Quality:

Motor Gasoline- antiknock quality, distillation, density, RVP, oxidation and storage stability, hydrocarbon composition, sulphur content, oxygenates, reformulated gasoline, trends in gasoline specifications, emission related properties and their effect on exhaust emissions, multi-functional additives and their benefits. Diesel- ignition quality, distillation range, density, viscosity, chemical composition, sulphur content, lubricity, trends in diesel specifications, emission related properties and their effect on exhaust emissions

- **Distribution of Lectures**

Name	**Designation**	**No. of Lectures**
Sh. A. K. Jain	Chief Scientist	15
Dr. S. K. Singal	Chief Scientist	10
Dr. B. P. Pundir	Ex. Prof. IIT Kanpur (External)	10
Sh. Sunil Kumar Pathak	Sr. Scientist	5

Course No: ENG(IIP): 3- 616
L-T-P-C: 2-0-2-3
Course Title: Automotive Test Equipments and Procedures – 3 Credits
Coordinating Faculty: Sh. Robindro L
List of Faculty: Sh. Robindro L, Sh. Wittison Kamei.

Course Description

Introduction: Engine testing and Vehicle Testing, Regulated, Un-regulated exhaust emissions, Emission Legislations, Indian Emission regulations, Test parameters i.e. Fuel, Emission Limits.

Engine dynamometer: working principles and types, **Chassis dynamometers:** Control strategy, types and application, **Measurement devices and conditioning systems**: Fuel balancer, Fuel mass flowmeter, Oil consumption meter, Air consumption meter, Temperature control systems, Smokemeter, Opacimeter.

Exhaust emission measurement systems: Raw & Diluted emissions, Classification of analysers (FID,CLD,NDIR,PMD) & their working principles, Portable emission analysers.

Dilution systems: Full flow & Partial flow system, Particulate matters (PM) measurement,

Engine test procedure: Test cycles, Steady State (13 mode), Transient Cycle (ETC), Load Response (ELR), Particulate Sampling, **Vehicle test procedure:** Test cycles, Coast down, constant speed test.

Calibration of emission measurement systems: analysers, constant volume sampler (CVS), Particulate system, calibration checks for engine dynamometer load cells, chassis dynamometer load cells.

Test start and operation: Test flow diagrams, Auxiliary equipments, Test conditions & preparations**,** Equipment operation, handling and maintenance.

PRACTICAL:

Engine dynamometer, Smokemeter, Fuel Balancer, Portable emission analyser, emission analysers (FID, CLD, NDIR of old AMA-2000 bench).

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Sh. Robindro.L	Scientist	20
Sh. Wittison Kamei	Scientist	10

Course No: ENG(IIP): 2- 617
L-T-P-C: 3-0-0-3
Course Title: Alternative Fuels – 3 Credits
Coordinating Faculty: Sh. S. K. Pathak
List of Faculty: Dr. S. K. Singal, Sh. S. K. Pathak, Sh. Vijayanad, Dr. Neeraj Atrey, Dr. Anil Sinha.

Course Description

Overview of Energy, Global and Indian energy scene, fuel resources and environmental policies; Conventional Fuels: Introduction, liquid and gaseous fuels and desirable properties of good IC engine fuels; Alternative fuels- General aspects, type of fuels and technical and policy challenges.

Alcohols: Methanol and Ethanol - Production, properties and application in engines, Ethanol and Gasoline blends and its application in vehicles, Ethanol and diesel blends and its application in C I engines; Butanol - Production, its application in SI and CI engines; ***Vegetable oils:*** Production and its application as I C engine fuel; Bio-diesel- Production and its properties; Bio-diesel- Application in engines/vehicles, F T diesel.

LPG: Conventional and new techniques of Production, Domestic and automotive fuel Properties, conversion system and technological advances, engine modifications, Regulatory codes, Performance and emissions, safety issues. ***Natural gas:*** Conventional and new techniques of Production, Automotive fuel properties, gas conversion system, First generation to third generation, engine modification, Regulatory codes, Performance and emissions, safety issues. ***Hydrogen:*** Conventional and new techniques of Production, properties, Induction Techniques for Hydrogen application in SI engines and CI engines; H2+Natural gas(HCNG), HCNG Properties; HCNG- conversion system; Regulatory codes; HCNG: Performance and emissions. ***Bio gas:*** Production and Properties, Bio gas- Application in engines/vehicles, NH3- Production and properties; NH3- Application in engines/vehicles, Producer gas- potential as I C engine application. ***DME:*** Production and properties, DME application in engine and technical issues and review of the work research and development carried out in the world

Alternative energy application for propulsion: Electrical vehicles, Hybrid vehicles, solar energy and solar powered vehicles, Fuel cell basics and type of fuel cells, Fuel cell vehicles. ***Miscellaneous:*** Alternative fuel powered vehicle evaluation as per Tap document, CMVR: Laboratory methods, Field Tests, Future Policy frame work for Alternative fuelled vehicles, Comparison of different alternative fuels based on vehicle usage and economics

- **Distribution of Lectures**

Name	**Designation**	**No. of Lectures**
Dr. S K Singal	Chief Scientist	5
Sh S K Pathak	Senior Scientist	14
Sh Vijyanand	Principal Scientist	7
Dr. Neeraj Atray	Senior Scientist	7
Dr Anil Sinha	Principal Scientist	2
Sh S K Pathak(Lab.)	Senior Scientist	5

Course No: ENG(IIP): 2- 594
L-T-P-C: 3-0-2-4
Course Title: Renewable Energy Conversion Technologies – 4 Credits
Coordinating Faculty: Dr S Kaul
List of Faculty: Dr. S. Kaul, Dr. T. Bhaskar, Dr. D. K. Adhikari, Dr. A Sinha, Dr. Ajay Kumar, Dr. Neeraj Atrey, Sh. D. V. Naik, Sh. Dinesh Bangwal.

Course Description

Introduction to renewable energy technologies; Energy scenarios and perspectives - past, present and future Non-renewable and renewable energy sources; description of renewable sources and their importance, current status, potential and future trends, renewable energy options for immediate and future directions. Technologies for biomass energy conversion i.e., pyrolysis, gasification, combustion, trans-esterification; fermentations, thermo-chemical conversions, value-added products from pyrolysis, thermal and catalytic methods for the upgrading of biomass; bio-refining products and applications. Solar energy sources, measurements, interconversions; Passive solar - architectural design, solar collectors; Solar energy conversion - photosynthesis and artificial photosynthesis; Photo-voltaic-semiconductor properties, performance criteria, manufacturing, economics; PV systems - installation, data collection and analysis. Historical background of wind resources - wind speeds and wind energy principles; Wind Turbines - system components, Environment Impact on applications. Ocean energy potential against wind and solar; Wave characteristics and statistics; Wave energy devices; Tide characteristics and statistics; Tide energy technologies; Ocean thermal energy; Osmotic power; Ocean bio-mass Geothermal Resources; Geothermal Technologies; Applications; Sustainable sources of hydrogen; Fuel cell technologies; Hydrogen storage and distribution; Applications and feasibility assessment; Science, technology and policy of energy conservation; Strategies for enhancing role of renewable energy.

- **Distribution of Lectures**

Name	**Designation**	**No. of Lectures**
Dr. Savita Kaul	Principal Scientist	12
Dr. T. Bhaskar	Senior Scientist	7
Dr. D. K. Adhikari	Chief Scientist	5
Dr. Anil Sinha	Principal Scientist	3
Dr. Ajay Kumar	Scientist	3
Dr. Neeraj Atray	Senior Scientist	3
Mr. D. V. Naik (Lab.)	Scientist	3
Sh. Dinesh Bangwal (Lab.)	Senior Technical Officer 3	4

Course No: ENG(IIP): 1-001
L-T-P-C: 1-0-0-1
Course Title: Research Methodology – 1 Credits

Course Description

Introduction; Research terminology and the scientific methods; Laboratory practices, discipline and safety practices; Types of Research; Research process and steps; Identifying a research problem; Literature survey and appreciation of existing literature; Conception of novel approach to solve the problem; Role of modelling and simulation; Design of experiment; Quantitative methods of data analysis; Qualitative analysis; Communicating Research results; Ethics in research. Case studies

CSIR-IMMT

ENGG (IMMT)-1-001: Research Methodology: 2-0-0-2

1. Research Methodology - Introduction

- Meaning, Concept, Need
- Historical Research
- Survey Research
- Experimental Research
- Fundamental and Applied Research

2. Literature Search & Review of Literature

3. Research Tools

- Measurement of Variables
- Presentation of Data
- Statistical Techniques – All Basic Techniques, Null hypothesis, Error Analysis, Interval estimation, Statistical Significance, *Examples:* Analysis of variance (ANOVA), Chi-squared test, Correlation, Factor analysis, Mann–Whitney U, Mean square weighted deviation (MSWD), Pearson product-moment correlation coefficient, Regression analysis, Spearman's rank correlation coefficient, Student's t-test and z-test, Time series analysis
- Statistical Packages:
    - **MS Excel** - Introduction, Getting Data into Excel, Activating the Data-Analysis Tools, Using Excel to Determine a Confidence Interval, Using Excel for t-Tests of Hypotheses, The t-Test for Independent Samples, The t-Test for Dependent (and Matched-Pair) Samples, Using Excel for ANOVA, Using Excel for Correlation, Using Excel for Linear Regression, Using Excel for Chi-Square Tests, The Chi-Square Goodness-of-Fit Test and the Chi-Square Test of Association
    - **MATLAB** - Introduction and Key Features, Developing Algorithms and Applications, Analyzing and Accessing Data, Visualizing Data, Performing Numeric Computation, Publishing Results and Deploying Applications

4. Research Types and Methods

- Observation Method
- Questionnaire Method
- Interview Method
- Experimental Method

5. Research Process

- Designing a Research: Characteristics, Purpose
- Research Plan
- Analysis and Testing
- Quantitative Methods and Data Analysis
- Qualitative Analysis

6. Communicating Research Results

- Journal paper
- Thesis
- Project proposal
- Report
- Web publishing
- Seminar and Oral presentations

7. Research Ethics and Plagiarism

8. Case Studies

Course Instructors: Dr. D.B. Ramesh, Dr. D. P. Sandha, Dr. D.P. Das

ENGG (IMMT)-2-626: Computational Methods & Numerical Analysis: 3-0-2-4

Computation & Programming: Notions of syntax and semantics of programming languages, Concept of algorithm, Systematic development of programs, Computer Architecture & Memory management, Object Oriented Programming & Data structure, parameter passing mechanisms, Program design practices.

Numerical Scientific Computing: Numerical differentiation & integration, Solving polynomial equations, Computational matrix, Transforms

Computer Graphics: Input / Output devices, Raster & Vector Graphics, Drawing algorithms; Windowing and 2D/3D clipping. 2D & 3D Geometrical Transformations, Viewing Transformations, Animation Techniques

Statistical Analysis: Statistical Concepts, Conditional Probability and independence, Regression Analysis, Design of Experiments, Support Vector Machine, Statistical Inference, Optimisation.

Practical/ Lab Work: Statistical Analysis using standard statistical package, application modelling using MATLAB, application programming practices with standard graphics libraries like open GL.

Course Instructors: Dr. D. P. Das, Mr. S. Rath

ENGG (IMMT)-2-627: Technologies for Mineral Resource Utilization: 3-0-2-4

Particulate technology, particle size distribution, sizing methodology, size-reduction and classification processes; Particulates in suspension, stability, Rheology and settling; Solid-liquid separation methods; Physics, chemistry, and engineering design as applied to gravity, magnetic, electrostatic, and froth flotation processes

Course Instructors: Mr. P.S.R. Reddy, Prof. D.D. Misra, Prof. B.K. Mishra

ENGG (IMMT)-2-628: Materials Characterization Technique: 3-0-2-4

Size and surface area analysis; Interaction of X-rays with matter, diffraction techniques and applications; Optical principles of microscopy; electron diffraction, imaging (various contrasts), determination of crystal structure, burgers vector, electron beam-specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro-Analyser; Principles of Quantitative Microscopy: Overview of other characterization techniques such as Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy.

Course Coordinator: Dr. B. K. Mahapatra

ENGG (IMMT)-2-629: Recycling of Material Resources: 3-0-2-4

Mining and metallurgical wastes classification, investigation and evaluation of waste deposits, waste and circulatory management during recycling.

Unit operations involving materials recycling processes such as pre-treatment (physical and chemical), roasting, calcination, sintering, leaching, solid-liquid separation; Solution, concentration and purification techniques—precipitation, cementation, solvent-extraction, evaporation, crystallization, electrowinning, electroremediation; Resources and recycling technologies across the major materials sectors, and case studies including wastes in steel and aluminium production; Recycling of E-wastes and secondaries; Economic evaluation and project implementation: Flow-sheet development, mass and energy balance, costing, techno-economic feasibility report (TEFR) preparation, financial investment in waste recycling, project planning and implementation, work safety.

Course Coordinator: Dr. K. Sanjay

ENGG (IMMT)-2-630: Process Instrumentation & Control: 3-1-0-4

Introduction to instrumentation in process industry, Different types of sensors and actuators, Computerized data acquisition, Monitoring and analysis of data (Time series and spectral analysis), Process control, PID Control, Introduction to PLC, SCADA & DCS, Networking and communication in industry, Artificial neural network & Fuzzy logic based control, Laboratory work.

Course Coordinator: Dr. D. P. Das

ENGG (IMMT)-2-631: Science for engineers: 3-0-0-3

Concepts of atomic and molecular energy levels leading to description of plasma state, plasma physics—thermal and non-equilibrium plasma, plasma diagnostics, methods of plasma processing of materials and minerals; Industrial plasmas, new concepts of resource utilization using plasma, Crystal structure and defects, electron and hole in lattices, Band gap module and tailoring : -optical and electrical, variable band gap.

Structure and Bonding; Molecular basis of chemical reactions, reaction kinetics, structural effect on reactivity; Complexation concepts, Spectroscopy, Metals in biological domain, Molecular engineering; Computational approaches for structure-function correlation, Surfaces and interfaces, Chemical theories involved in solution, concentration and purification, Micelles, surfactants and their application for bulk processing of mineral resources.

Cell types structure and function; Bio-molecules: composition and bonding; Overview of amino acids, proteins, carbohydrates, nucleic acids, lipids, enzymes, vitamins and minerals; DNA replication; Membranes, Introduction to bio-mineral processing.

Course Coordinator: Dr. Bikash K. Jena

ENGG (IMMT)-2-632: Fundamentals of Engineering Analysis: 3-0-0-3

Fundamental concepts of fluid flow, heat and mass transfer; Shell balance approach for molecular and convective transport processes;
Formulation and solution of ordinary and partial differential equations that describe physical systems of importance in engineering; some applications to minerals and materials processing
Numerical methods: finite difference, numerical solution of ordinary and partial differential equations.

Course Instructor: Dr. Swati Mohanty

ENGG (IMMT)-2-633: Process Design & Simulation: 3-0-2-4

Preliminary resource evaluation methods; Identification and development of process flow sheet; Elementary evaluation of plant performance; Spread-sheet development for plant data analysis; Introduction to simulation environment using MODSIM, simulator structure, numerical analysis of simulation, sequential method of simulation, practical application of plant simulation; Materials and energy balance, mass balance smoothing, data reconciliation in terms of grade and recovery, analysis of complex flowsheet for mass balancing, examples of material balance smoothing; Application of modeling and residence time distribution concepts for plant data interpretation; Parameter estimation: linear regression, one, two, and multi-linear regression; models nonlinear in parameters; Case studies of typical process plant design and operation.

Course Instructors: Prof. B. K. Mishra, Dr. C. Eswariah

ENGG (IMMT)-2-634: Advanced Extraction Methods: 3-0-0-3

Fundamentals of commercially important nonferrous pyrometallurgical extraction processes; Thermodynamics of high-temperature processes and solid-gas reaction kinetics; Heterogeneous kinetics, multi-phase systems, Electrodics, Semiconductor electrochemistry; Application: roasting, sulphide-oxide-sulphate systems, oxide-chloride systems, smelting, kinetic analysis, bath smelting, dynamic contact angle-free energy correlation; Electro-smelting—present practice and future trends; Direct electrowinning, possible electrode systems, conduction types, future trends.

Course Instructor: Dr. R. K. Paramguru

ENGG (IMMT)-2-635:Advanced Topics in Materials Resource Engineering:3-0-2-4

Plasma Processing

Introduction, Basic plasma and gas discharge concepts, Glow discharge plasmas, Thermal plasmas, Plasma torches and sprays, Plasma chemistry, etching and polymerization, Plasma coatings, Diamond and diamond-like films, Diagnostics/Probes, Plasma Spraying, Preparation of nano powders, Plasma smelting, Plasma sintering

Powder Metallurgy

Production of metal and alloy powder, particle size & shape, microstructure, Powder compaction, Sintering (Solid state sintering & Liquid phase sintering), Hot pressing, Sintering furnaces & atmospheres, Applications of powder metallurgy.

Corrosion Science & Engineering

General introduction, Electrochemical reactions, Thermodynamic concepts, Eh-pH diagram, Prevention of corrosion

Rheology

Fundamentals, Types of viscometers and rheometers, Applications

Course Coordinator: Dr. S.K. Singh

ENGG (IMMT)-2-636: Energy & Environment: 3-0-2-4

Important Indian minerals & related environmental issues; Environmental impact due to mining in Orissa; Case study on graphite resources of Orissa and environmental management, Environmental issues related to mining, processing and products – solid wastes**,** Environmental impact analysis and management plan, Case studies related to environmental management of minerals and materials industries; Effluent treatment (nutrients removal) through microbial activity, Vulnerability and adaptation technologies for sustainable development, Pollution generation and management – Effluents, Environmental laws and global issues related to environment, Conservation of energy in different production and processing steps, Energy audit in mineral and material processing industries.

Course Coordinator: Dr. B. C. Acharya

ENGG (IMMT)-2-637: Mineralogy and Mineral chemistry: 3-0-2-4)

Process mineralogy, Liberation Studies using QEMSCAN, Mineral chemistry using EPMA, Identification of mineral phases through XRD.

Geochemistry : Chemical composition of the Earth, elementary statistics for geochemistry; major, minor and trace elements including rare earth elements; element partitioning between minerals and melts; petrogenesis, Geochemical Classification of elements, Geochemical differentiation, Isomorphism, Polymorphism, Atomic substitution and Geochemical cycle.

Analytical Geochemistry: Chemical analysis of rocks and minerals, digestion techniques, preparation of standards, estimation of major oxide percentages using spectrophotometric /flame photometric and titrimetric methods. Preparation of calibration curves. Gravimetric estimation of silica and R2O3. Determination of noble metals. Introduction to Neutron Activation Analysis, principles of ICP, XRF & AAS analysis.

Statistical Methods in Geosciences: Introduction to probability: random experiments, events, sample space, definitions of probability. Conditional probability and independence of events, Bayes theorm. Random variables, discrete and continuous probability distributions, joint probability distributions, conditional probability distributions. Mathematical expectation, moment generating and characteristic functions. Binomial, Poisson, Normal, Gamma, Exponential, Hypergeometric, Multinomial, Chi-square, t, and F distributions. Introduction to statistical inference, sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations. Linear models ANOVA. Linear and multiple regression. Introduction to multivariate techniques PCA, factor analysis, linear discriminant analysis, classification

ENGG (IMMT)-3-626: Computational Fluid Dynamics: 3-0-2-4

Introduction to Computational fluid dynamics; Conservation equations: momentum, energy and mass balance equations; Discretization methods: Finite difference method, Finite element method, Finite volume method; Structured and unstructured grid; Multiphase flows: fluid-fluid, fluid-solid; Turbulence modeling: Direct Numerical Simulation, Large Eddy Simulation, Reynolds Averaged Navier Stokes model; CFD modelling of some mineral and material processing unit operations; Introduction to CFD software.

Course instructor: Dr. Swati Mohanty

ENGG (IMMT)-3-627: Advanced Materials: Characterization and Processing: 3-1-2-4

Theory: Fundamentals of crystallography, crystal structure and structure determination by XRD, electron diffraction and neutron diffraction in polycrystalline materials, stereographic projection and pole figures, orientation and texture analysis, structure of metals, alloys, solid solution, concept of amorphous, glassy and nano materials and their characterization, defects in crystals, theory of dislocation, Burger vector, plastic deformation, stress measurement by XRD, strengthening mechanism, cold working and heat treatment of steel, hardness and tensile test of steel, concepts in fracture mechanics and fracture determination methods, S-N curve, low cycle fatigue, fatigue mechanism.

Practical: Study of types of high temperature furnaces including plasma furnace, induction and vacuum induction furnace, study and determination of vacuum in rotary and diffusion pumps, high temperature determination by thermocouple and pyrometer, morphology and microstructure observation by various microscopy methods (SEM, TEM, AFM, optical), XRD, Raman spectroscopy and identification of impurities and precipitates in metals,

microhardness and nanoindention measurements, tensile, fracture toughness and fatigue tests of steel.

Course Coordinator: Dr. B. B. Nayak

CSIR-National Chemical Laboratory

Eng(NCL)1-001: Research Methodology 2-0-0-2 2 credits

Course Objective

To review data analysis fundamentals, teach common research techniques from literature survey and organization to effective communication, ethics, lab safety practices.

Modules

- Scientific literature survey and reference management
- Scientific writing and presentation
- Intellectual Property Management
- Ethics in Science
- Maintenance of lab records
- Lab safety and first-aid
- Quantitative methods and data analysis

Eng(NCL):1-003: Numerical Methods and Programming 3-0-0-3 3 credits

Course Objective

To understand the algorithms involved in the numerical methods used for computer simulation, have the ability to choose an appropriate algorithm and be aware of the advantages and pitfalls expected in a particular algorithm. Computer implementation of algorithms and use of Matlab or other subroutines.

Modules

- Introduction to Programming, linux, introduction to Matlab/Scilab/Octave
- Matrix operations
- Function approximations, solutions of system of nonlinear equations
- Numerical methods for ODEs
- Finite-difference/volume methods for PDE
- Optimization approaches

Eng(NCL):1-701: Mathematical fundamentals 3-0-0-3 3 credits

Course Objective

To review mathematical fundamentals, teach common mathematics prerequisites of other courses, and to impart perspective on modeling and simulation.

Modules

- Analysis basics
- Linear Algebra
- Ordinary and partial differential equations
- Optimisation

Eng(NCL):1-702: Reaction and Reactor Engineering 3-0-0-3 3 credits

Course Objective

To develop the understanding of the reactions from molecular scale to the reactor scale, and to equip the student to model different reactor configurations and non-idealities in reactor systems.

Modules

- Chemical kinetics
- Homogeneous reactor analysis and design
- Heterogeneous reactor analysis and design
- Special reactors

Eng(NCL):1-703: Transport phenomena 3-0-0-3 3 credits

Course Objective

To develop a good physical understanding of the processes of momentum, heat and mass transfer at the continuum level; to develop the mathematical tools to solve problems in transport phenomena

Modules

- Linear algebra and calculus relevant to transport phenomena
- Conservation equations
- Examples in transport phenomena

Eng(NCL):1-704: Thermodynamics and Statistical Mechanics 3-0-0-3 3 credits

Course Objective

To develop the understanding of thermodynamics principles as applicable to chemical systems.

Modules

- Classical Thermodynamics, ideal gases
- Solution thermodynamics
- Equilibrium thermodynamics
- Non-equilibrium thermodynamics
- Ensemble methods

Eng(NCL):2-711: Multiscale simulations in materials 3-0-0-3 3 credits

Course Objective

To be familiar with simulations at the molecular and sub-molecular scale, including quantum chemistry based and classical mechanics based methods.

Modules

- Introduction to molecular modeling
- Quantum-chemistry driven modeling
- Classical mechanics based modeling

- Example problems at multiple scales

Eng(NCL):2-712: Industrial flow modeling 3-0-0-3 3 credits

Course Objective

To teach students the basic equations of fluid dynamics and computational methods to solve these equations as applied to flows in industrial processes. At the conclusion of the course students will be able to analyze complex flow situations, develop a simple model for complex flow and solve it numerically, and simulate the actual complex flow using available CFD software.

Modules

- Introduction to CFD
- Solution techniques for solving CFD equations
- Introduction to CFD Software
- Turbulence modeling
- Multiphase flows

Eng(NCL):2-713: Data driven modeling 2-0-0-2 2 credits

Course Objective

The course will emphasize the conceptual understanding of methods along with their implementation in real world scenarios. At the end of the course, the student is expected to be able to identify and implement appropriate conventional, machine learning or AI based methods for linear/non linear data fitting, data reduction, and classification.

Modules

- Statistics basics
- Supervised learning
- Unsupervised learning
- Artificial intelligence based methods
- Model validation
- Practical applications in data reduction, feature selection, classification.

Eng(NCL):2-714: Non-linear dynamics 3-0-0-3 2 credits

Course Objective

Introduce methodologies for analyzing complex nonlinear behavior with examples from reaction engineering, chemical, and physical systems. Students will learn (1) how nonlinear systems differ from linear systems regarding their dynamical properties; (2) how to analyze the stability of complex systems ; (3) how sensitivity of system dynamics is related to predictability and control; (4) to explore dynamical systems analytically and with computer simulations

Modules

- Introduction to the dynamics of nonlinear systems
- Preliminary analysis of time-series data:
- Toy “Nonlinear models” and the role of parameters
- Stability of solutions to ODEs
- Properties of chaos:
- Self organizing properties of nonlinear systems

- Phase space analysis

Eng(NCL):2-715: Modeling of biological systems 3-0-0-3 3 credits

Course Objective

Provide a brief background of biological systems for model development. Bioreactor design and analysis. Metabolic network modeling using constraint based approaches and signaling pathway modeling using deterministic and stochastic modeling techniques.

Modules

- Biological fundamentals
- Bioreactor models
- Metabolic pathways
- Signaling pathways
- Pharmacokinetics and pharmacodynamics

Eng(NCL):2-716: Advanced separation processes 2-0-0-2 2 credits

Course Objective

Provide understanding of the principles underlying various separation processes.

Modules

- Mass transfer and thermodynamics applications to separations
- Unit operations in separation: adsorption, distillation etc
- Fundamentals of separation equipment design

Eng(NCL):3-701: Advanced topics in materials and processes 2-0-0-2 2 credits

Course Objective

An in-depth study of specific topics well beyond material available in textbooks. As appropriate, it may include specialized training on high-end equipment that is not normally part of a MTech level lab course.

Eng(NCL):3-702: Advanced topics in chemical engineering science 2-0-0-2 2 credits

Course Objective

An in-depth study of specific topics well beyond material available in textbooks. Envisaged as a discussion of recent papers and projects on areas extending the currently published work.

Eng(NCL):2-701 to 2-704: Lab courses 0-0-4-2 2 credits

Course Objective

Training in planning, executing, analyzing and reporting results from an experimental study in several disciplines, ranging from introductory experiments to advanced training in use of sophisticated equipment.

Eng(NCL):2-696 to 2-699: Seminar Participation 0-1-0-1 1 credit each

Course Objective

Provide exposure to current research and societal activities through talks by eminent scientists and other speakers. Students will be required to attend approximately 10 talks every semester.

Research Proposal I and Research Proposal II 0-0-4-2 02 x 2 =4 credits

Course Objective

State-of-the art review, methodologies, recommendations etc. for two topics of high relevance and novelty

Eng(NCL):2-700: Symposium participation 0-0-2-1 01 credit

Course Objective

Provide exposure to current topics through scientific talks and poster session, and an opportunity to showcase research ability and results to potential employers. Students are expected to present posters and interact with participants from industry and academia.

Eng(NCL):3-699: Critical survey 0-0-4-2 02 credits

Course Objective

State-of-the art review, methodologies, recommendations etc. for topic related to thesis research.

CSIR-SERC Campus

ENG(SERC): 2-930: Renewable Energy Sources for a Sustainable Future Course coordinator: Dr. Bala Pesala Faculty: Dr. Saptarshi Sasmal, Shri. K. Srinivas, Dr. Carmalin Sophia	(2-0-0-2) 2 Credits

The course provides a brief overview of the field of the renewable energy covering scientific, technological and pricing aspects.

Course Content:

- Basic thermodynamics: Laws of thermodynamics, Energy and entropy, Carnot efficiency
- Non-renewable sources and climate change discussion
- Introduction to various renewable technologies (solar, wind, hydro, geothermal etc.)
- Decentralized hybrid power: Need and potential in Indian context
- Instrumentation and sensors for power monitoring
- Structural Design basics: Engineering mechanics
- Energy costing and comparison with non-renewables

ENG(SERC): 2-931: Harnessing the power of Sun: Science and Technology of Solar Photovoltaics Course coordinator: Dr. Bala Pesala	(3-0-2-4) 4 Credits

Solar photovoltaics shows the biggest promise to solve the energy crisis. This course is designed to provide a solid scientific base for understanding and designing various solar cells and hands-on experience to test and evaluate the performance of solar cells.

Course Content:

- Solar cell introduction: Shockley-Queisser limit, efficiency
- Introduction to semiconductors: Direct/Indirect band gap semiconductors, Energy band structure of solids and band diagrams
- Basic semiconductor electronics: p-n junctions, diodes, transistors, heterostructures
- Quantum mechanics: Schrodinger equations, Kronig-penny model, Quantum potential wells
- Detailed discussion of various solar PV technologies (Si, Thin film, GaAs etc.)
- Design and simulation of solar cells

Lab:

- Solar cell design using TCAD/Matlab
- Testing and characterization of solar cells (Si, Multijunction, Thin film) (Current-voltage characteristics, efficiency)

ENG(SERC): 2-932: Energy Storage and Conversion: Science & Technology Course Coordinator: Dr. A. S. Prakash Faculty: Dr. S. D. Bhat, Dr. K. Ramesha, Dr. A. K. Sahu	(3-0-2-4) 4 Credits

This course will cover introduction, basic principles and science & technology of various energy storage and conversion systems

Course Content:

- Introduction to energy storage: thermal, mechanical, compressed air, pumped hydro & chemical energy.
- Electrochemical energy storage: Batteries, super capacitors and fuel cells
- Battery basic concepts: Cell voltage, capacity, energy/power density, primary and secondary batteries, thermodynamics, working principles, electrode process.
- Battery types: Lead acid, Ni-Cd, Nickel-metal hydride, lithium ion.
- Batteries for EV, solar applications and recent advances.
- Dye-sensitized solar cells
- Fuel cells: Types of fuel cells, materials & components, applications, thermodynamics, kinetics, system design and engineering, hydrogen storage.
- Dye sensitized solar cells:
- Comparison of various energy storage systems, cost economics, market trends

Lab:

- Fuel cell stack fabrication, assembly & testing,
- General electrochemical characterization, cyclic voltametry, chronoamperometry, half-cell studies.

ENG(SERC): 1-002: Mathematics for Engineers (1-1-0-2)
Course Coordinator: Dr. Madan Kumar Lakshmanan 2 Credits

This is a refresher program that provides an overview of mathematical fundamentals essential to grasp the advanced concepts of renewable energy engineering. It is devised to impart key mathematical skills to students from diverse disciplines and expose them to various numerical/computational tools.

Course Content:

- Linear algebra: Matrices, system of linear equations, linear transformations, vectors, vector spaces, inner product spaces, Eigen vectors and eigen values, orthogonal projection.
- Transforms: Fourier series, Fourier transform (FFT, DFT, DTFT), Laplace transform, Z-transform, Wavelet transform, Karhunen–Loève theorem.
- Differential equations: Introduction to differential equations, first/second order differential equations, Partial differential equations, geometrical interpretation
- Integrals: Definite integrals, indefinite integrals, line and surface integrals, integrals of differential forms.
- Sequences and series: convergence of series, finite and infinite series, Taylor and Laurent series expansions.
- Mathematical and computational tools: Matlab, Mathematica

ENG(SERC): 2-933: "View from the TOP" Seminar Series I (1-0-0-1)
Course Coordinator: Dr. Bala Pesala 1 Credit

Seminar aims at giving exposure as to how the best quality science is pursued, what drives the scientists and their experiences in overcoming various hurdles during their scientific pursuit

- Talks by leading scientists in CSIR
- Invited talks by various professors on specialized topics in energy

Invited speaker list*:

Dr. Samir Brahmachari , DG, CSIR
Dr. Nagesh Iyer, Director, CSIR-SERC
Dr. Chandra Shekhar, Director, CSIR-CEERI
Dr. Ehrich Desa, Director, CSIR 800

Prof. Connie Chang-Hasnain (Professor, UC Berkeley)
Prof. Eli Yablonovitch (Professor, UC Berkeley)
Prof. P.C. Ku (Professor, University of Michigan)
Prof. Tonio Buonassisi (Professor, MIT)
Dr. Arun Majumdar (Director, ARPA-E, U.S.A)
Prof. Ramesh Ramamoorthy (Director, Sunshot Initiative, DOE, U.S.A)
Prof. Anand Veeraraghavan, University of Queensland, Brisbane, Australia

ENG(SERC): 2-934: Design and Engineering for Sustainability Course Coordinator: Dr. Saptarshi Sasmal Faculty : Dr. Prabhu Rajagopal (IIT Madras)	(1-0-2-2) 2 Credits

This course provides a generic overview of the principles needed for the design and engineering of various systems and products.

Course Content:

- Design approaches
  - Multi-objective design
  - Design optimization
  - Metrics for design evaluation
- Design for 'X'
  - Manufacturing and assembly
  - Ergonomics
  - Inspectability and sustainability
- Practical aspects of design
  - CAD
  - Manual prototyping
  - Automated prototyping (3D printing/Rapid prototyping)

Lab:
Solve a design problem with a given constraints
Ex: Solar lantern that can replace a kerosene lamp at a competitive cost

ENG(SERC): 2-935: "View from the TOP" Seminar Series II Course Coordinator: Dr. Bala Pesala	(1-0-0-1) 1 Credit

Seminar to expose students to the real problems in the energy sector and the need for innovative technological solutions, unique business models to make renewable energy sustainable especially in a decentralized setting and for people at the BOP

- Talks by various entrepreneurs and executives from industry working in renewable energy

Invited speaker list*:

Dr. Harish Hande, SELCO, India
Dr. Bunker Roy, Founder, Barefoot college, Tilonia

Mr. Anshuman Lath, CEO, Gram Oorja
Mr. Sai Baba, Lanco Solar
Mr. Carlos Treves, High-flex solar, U.S.A
Dr. Nasreen Chopra, Altadevices, U.S.A
Dr. Bernardo Costanova, LS13, U.S.A

ENG(SERC): 3-930: Solar Photovoltaics: Power Electronics, Power Transmission and Energy Monitoring (3-0-2-4) 4 Credits
Course Coordinator: Dr. Bala Pesala
Faculty: Shri. K. Srinivas, Shri. Suriya Prakash, Shri. G. S. Aiyappan

Utilization of solar photovoltaic energy for various applications requires appropriate power conversion devices/electronic systems and instrumentation for real time monitoring. This course provides an in-depth understanding of these fields.

Course Content:

- Power electronics: Power devices (BJT's, MOSFETs, IGBT's)
- Microcontrollers/Embedded controllers, Charge controllers
- Inverters and rectifiers
- Control systems (active/passive controls), Maximum power point tracking
- Single/dual axis tracking systems: Design and implementation
- Sensors and instruments for monitoring: Power, Voltage, light intensity, Battery charging/discharge cycles
- Remote monitoring: Wired/wireless/Power line, Wireless technologies (GSM/Wi-fi/Zig-bee) and smart power meters
- Smart grid systems: Transmission (AC/DC), Grid connection topologies/super grids for renewable energy, HVAC-HVDC cost analysis and utility

Lab:

- Solar module performance monitoring
- MPPT design and implementation
- Matlab toolbox for sensor and instrument progamming and monitoring
- Remote monitoring using Zig-bee communication

ENG(SERC): 3-931: Advanced course on Lithium-Ion Batteries (3-0-2-4) 4 Credits
Faculty: Dr. K. Ramesha , Dr. A. S. Prakash

This course gives concise understanding of electrochemistry and comprehensive knowledge on Lithium-ion batteries with detailed understanding of components and materials chemistry. The course also involves complete understanding of various characterization tools used in materials science such as XRD, SEM, TEM and electrochemical analysis. Hands on experiments are formulated to cover all aspects - from synthesis, characterization to complete assembly of Li-ion battery cells.

Course Content:

- Introduction to batteries: Historical perspective, Kinetics/thermodynamics/charge transfer process, Faraday’s law of electrolysis, standard cells and electrode potentials
- Lithium battery active materials: Anode: intercalation, conversion, alloying; Cathode: Layered, framework structures
- Electrolytes: organic, polymeric, ionic liquids. Aprotic organic electrolytes, Polymer electrolytes-dry, gel and composites, polymer membranes.
- Separators: materials, properties, porosity, thermal, mechanical and electrochemical stability.
- Safety, assembly and recycling
- Synthesis approaches for battery materials and crystallography

- Instrumental methods in Li-ion battery research: XRD analysis, microscopy (SEM, TEM), thermal analysis (TGA, DTA, DSC), IR, Raman analysis, GITT, impedance analysis etc.

Lab:

- Li-ion battery fabrication, material preparation (cathode, anode).
- Materials characterization (XRD, SEM, TEM, TGA, etc).
- Electrochemical tests on Li-ion batteries (CV, charge-discharge, capacity, life cycle studies, GITT, EIS).

ENG(SERC): 3-932: Design of Structures For Renewable Energy (2-1-2-4)
Course Coordinator: Dr. Saptarshi Sasmal 4 Credits
Faculty : Dr. J. Rajasankar, Dr. P. Harikrishna, Shri. G. Ramesh Babu

The course is aimed at enabling the scholars to conceptualise, analyze and design structures for renewable energy sources such as solar and wind, specifically, the solar PV modules and wind turbines.

Course Content:

- Fundamentals of Structural Mechanics: Introduction to structural mechanics, Kinetics, Kinematics and Energy theorems
- FEM techniques for structural analysis: Stationary principles, Rayleigh-Ritz method and interpolation, Iso-parametric finite element, shape function, modeling, numerical integration, coordinate transformation
- Design Concepts: Limit states, LRFD, fatigue for concrete/steel/composite structures
- Support structures for solar photovoltaic modules: Loads and analysis, design
- Support structure for wind turbines - Loads and analysis, design of superstructure and foundation
- Wind turbine blades: Stress analysis and design

Lab:

- Structural form effect
- FEM applications
- Wind tunnel-scaled modelling of structures

ENG(SERC): 3-933: Bio Energy: The Plants Work & Let Us Reap (3-0-2-4)
Course Coordinator: Dr. Carmalin Sophia 4 Credits
Faculty: Dr. Rima Biswas

Bioenergy module is developed keeping in mind the energy sectors imminent and future need for personnel with green energy skills. The module provides an introduction to the Bio-energy, sustainability, issues and framework required appreciate the significance of bio-energy related matters with and industrial environment

Course Content:

- Introduction to bio-energy
- Bio-energy sustainability: Land use, bio-energy crops, feed stocks and crop harvesting, Agronomy of bio-energy crops, Environmental implications
- Chemistry & biochemistry of Biomass
- Biochemical processes (conversion, deconstruction, bio-processing)
- Bio-fuels (ethanol, bio-butanol, biodiesel, cellulosic and other biofuels)
- Physical and chemical processes (combustion, gasification, pyrolysis)
- Direct biomass combustion & Co-firing technologies
- Power generation from bio-mass

- Economics of bio-energy (costs, prices, markets, financing and marketing
- Policies & Future R&D of Biofuels & Bioenergy

Lab:

- Microbial conversion of plant derived biomass into bio-fuels
- Pre-treatment technologies to make the lignocellulose more accessible to enzymes, hydrolysis of polysaccharides to sugars, conversion to a fuel molecule, and extraction of the fuel
- Microbial fuel cell/ Microbial electrolysis cell, Microalgal biofuels
- Thermo-chemical, chemical and catalyst conversion of biomass/Gasification
- Bio-energy systems engineering

ENG(SERC): 1-930: Effective Presentation Skills and Dissertation Writing Course Coordinator: Dr. Bala Pesala	(1-0-0-1) 1 Credit

This course teaches effective presentation skills and valuable tips on dissertation preparation and writing.