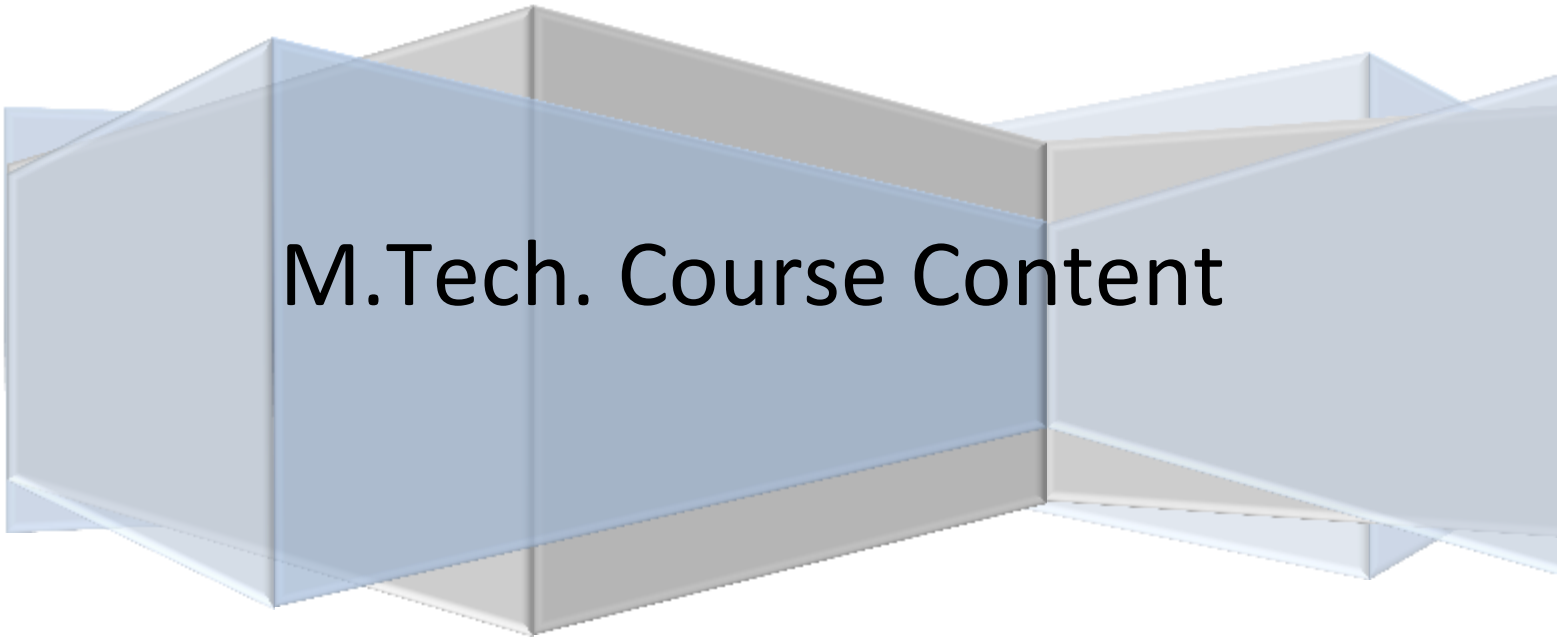

M.Tech. Course Content

CSIR-CBRI

Building Engineering & Disaster Mitigation

Building Engineering and Disaster Mitigation (BEDM)

M.Tech. Course structure

SEMESTER I			SEMESTER II		
Course Code	***Course Title***	***L-T-P-C***	***Course Code***	***Course Title***	***L-T-P-C***
ENG(CBRI) 1-137	Numerical Methods	3-0-0-3	ENG(CBRI) 1-136	Design of Building Structures	3-0-0-3
ENG(CBRI) 1-139	Advanced Geotechnical and Foundation Engineering	3-0-0-3	ENG(CBRI) 1-138	Disaster Resistant Building System-I	3-0-0-3
ENG(CBRI) 1-141	Engineering Materials for Infrastructure	3-0-0-3		**Elective I**	3-0-0-3
ENG(CBRI) 1-143	Analysis of Building Structure	3-0-0-3		**Elective II**	3-0-0-3
ENG(CBRI) 1-145	Research Methodology for Engineers	1-0-0-1		**Elective III**	3-0-0-3
ENG(CBRI) 1-147	Laboratory – I (Geotechnical Engineering, Materials and Environmental Science & Technology)	0-0-4-2	ENG(CBRI) 1-166	Laboratory-II (Structural Engineering & Fire Engineering)	0-0-4-2
ENG(CBRI) 1-149	Seminar-I	0-0-2-1	ENG(CBRI) 1-168	Seminar-II	0-0-2-1
Total Credits		***16***	***Total Credits***		***18***
SEMESTER III			**SEMESTER IV**		
Course Code	***Course Title***	***L-T-P-C***	***Course Code***	***Course Title***	***L-T-P-C***
ENG(CBRI) 2-137	Disaster Resistant Building System–II	3-0-0-3	ENG(CBRI) 2-136	Dissertation-II including Viva Voce	0-8-24-20
ENG(CBRI) 2-139	Dissertation-I	0-4-16-12			
Total Credits		***15***	***Total credits***		***20***
Total Credit : 69					

For details of the Ph.D programme refer to the Ph.D brochure.

ELECTIVE COURSES

Course Code	Course Title
ENG(CBRI) 1-140	Concrete Technology
ENG(CBRI) 1-142	Planning, Regulations & Management of Buildings
ENG(CBRI) 1-144	Industrialized Building Systems
ENG(CBRI) 1-146	Repair, Rehabilitation & Retrofitting of Building Structures
ENG(CBRI) 1-148	Environmental Impact Assessment
ENG(CBRI) 1-150	Sustainable Design & Energy Efficient Building Systems
ENG(CBRI) 1-152	Construction, Planning & Management
ENG(CBRI) 1-154	Fire Protection Engineering
ENG(CBRI) 1-156	Environmental Engineering & Management
ENG(CBRI) 1-158	Advanced Seismology
ENG(CBRI) 1-160	Engineering of Problematic Soil
ENG(CBRI) 1-162	Optimization Techniques
ENG(CBRI) 1-164	Deep Excavation
ENG(CBRI) 2-138	Health Monitoring of Building Structures
ENG(CBRI) 3-136	Tall Buildings & Structures
ENG(CBRI) 3-138	Behaviour of Metal Structures
ENG(CBRI) 3-140	Rock Mechanics
ENG(CBRI) 3-142	Landslide Disaster Mitigation

Note: The electives will be selected by the students depending on their broad areas of research.

Core Courses SEMESTER I

ENG(CBRI) 1-137	Numerical Methods	L-T-P-C 3-0-0-3
Syllabus	Interpolation, Errors in interpolation. Divided differences, polynomial approximation, Numerical Differentiation and Integration, Matrices: Eigen values and corresponding Eigen vectors Numerical solution of ordinary differential equations, Convergence Numerical solution of Partial Differential Equations, Initial value problem, Boundary value problem, Laplace and Poisson equations, completeness & stabiltity Special fuctions: Lagendre's function, Rodrigue's formula, Bessel's function and recurrence formula, 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	
Reference Books	1. Jain, Iyenger, Numerical Methods for Scientific and Engineering Computations, Wiley, 1987. 2. Grewal, B.S. Numerical Methods in Engineering & Sciences,Khanna, New Delhi. 3. E. Kreyszig, Advanced Engineering Mathematics. 4. S. Chakrabarti, Bhatt, R.B., Numerical Methods in Engineering, Narosa Publ. House, 2004. 5. S S Sastry, Introductory Methods of Numerical Analysis, Prantice Hall. 6. John Mathew & Kurtis Fink, Numerical Methods with MATLAB, Prantice Hall. 7. C.F. Gerald (5/e), Applied Numerical Analysis, Addison Wesley, 1994. 8. O.C. Zienkiewicz, The Finite Element Methods, Tata Mcgraw Hill publishing Co., New Delhi. 9. C.S. Desai & J.F. Abel, Introduction to Finite Element Method. 10. Rao, S.S., The Finite Element Methods in Engineering, Pergamon, New York. 11. Gupta & Goyel, Special functions	
Faculty	S.K. Bhattacharyya & Abha Mittal	

ENG(CBRI) 1-139	Advanced Geotechnical and Foundation Engineering	L-T-P-C 3-0-0-3
Syllabus	**Introduction to Geotechnical engineering –** Fundamentals of soil mechanics and foundation engineering. **Deep foundation** - Pile Groups – Axial capacity of pile groups-Consideration regarding spacing – Efficiency of pile groups – Stresses on underlying soil strata – Approximate analysis of pile groups – Settlement of pile groups – Under reamed piles. **Ground Improvement Techniques** – Introduction-Need of Ground improvement –Different methods of ground Improvement- preloading, prefabricated vertical drain, soil grouting, stone column, sand column, lime column, cement column, dynamic compaction, blasting, vibroflotation etc.- Applicability of different methods - Quality control in ground improvement works. **Stability of Slope –** Introduction - Different methods of analysis-Dynamic slope stability - Long and short term stability - Factors affecting stability of a slope – Slope protection. **Reinforced Soil –** Introduction-Mechanism of reinforced soil - Soil-reinforcement interaction-different types of soil reinforcement –Application of reinforced soil – Design of Reinforced earth wall (static and dynamic), reinforced soil for foundation. **Environmental Geotechnics**: Contamination, contaminant transport and waste containment, slurry wastes, Liners, Stability of landfills, landfill construction, Design aspects, Barriers.	
Reference Books	1. Bowles J.E., "Foundation Analysis and Design" (4Ed.), Mc.Graw –Hill, NY, 1996 2. Poulos H.G. and Davis E.H., "Pile foundation Analysis and Design", John-Wiley & Sons, NY, 1980 3. M.J Tomlinson (1975) "Foundation Design and construction", Pitman Publishing Limited, London 4. Bell, F.G., 'Ground engineering Reference book', Butterworth 5. Shashi K Gulhati and Manoj Datta., 'Geotechnical Engineering', Tata McGraw-Hill. 6. Hari.D.Sharma and Krishna R. Reddy., Geoenvironmental Engineering, John wiley & sons 7. Saran, S., Reinforced soil and its Engineering applications, I.K.International. 8. Brand, E.W, Brenner, R.P, Soft Clay Engineering. 9. Manfred R. Hausmann, 'Engineering principles of ground modification, Mc-Graw Hill	
Faculty	A. Ghosh, S. Karthigeyan & Manojit Samanta	

ENG(CBRI) 1-141	Engineering Materials for Infrastructure	L-T-P-C 3-0-0-3
Syllabus	**Building Materials:** Introduction to building materials - Conventional building materials (ceramic, glass, and gypsum) - Non-conventional building materials (fly ash bricks, sand lime bricks, polymeric materials, reconstituted wood products, and geo-synthetic materials) - Advanced building materials (composites, geo-polymers, corrosion protective coatings, polymer concrete) - Methods of characterization of building materials (hygroscopicity, weathering, water permeability, frost resistance, thermal conductivity, heat capacity, chemical resistance, and durability), instrumental techniques, - Effect of UV, Humidity and thermal exposure on organic building materials and preventive techniques (effect of UV, humidity and temperature on building material properties, safe limits, physical & chemical factors, biological factors and remedial measures). Types of cements, characterization techniques, Cement hydration and micro-structural development, chemical admixtures, super plasticizers, air-entraining admixtures, retarders, corrosion inhibitors, shrinkage reducing admixtures.	
Reference Books	1. Duggal S. K., Building Materials, New Age International, 3rd Edition 2008. 2. Varghese P. C., Building Materials, PHI Publication, 3rd Edition, 2008. 3. Jagadish K. S., Reddy B. V. V., Rao K. S. N., Alternative Building Materials and Technologies, New Age International, 2006. 4. Rixom R. and Mailvaganam N., "Chemical Admixtures for Concrete", 3rd Edition, E&FN Spon, 1999. 5. Aitcin P. C., "High Performance Concrete", E&FN Spon, 1998. 6. Mehta P. K., and Monteiro P. J. M., "Concrete Microstructure, Properties and Materials", 7. 3rd Edition, Tata McGraw Hill, 2006. 8. Taylor H. F. W., "Cement Chemistry", Thomson Telford, 1997. 9. Perkin P. H., "Repair, Protection and Waterproofing of Concrete Structures", 3rd Edition, E&FN Spon,	
Faculty	Rajni Lakhani & S.K.Singh	

ENG(CBRI) 1-143	Analysis of Building Structure	L-T-P-C 3-0-0-3
Syllabus	**Static analysis** - Fundamentals of elasticity, Static and kinematic indeterminacy, stiffness and flexibility methods, Finite element formulation of 1D, 2D and 3D problems, Analysis of plane stress, plane strain, axi-symmetric and plate bending problems, Application problems using finite element technique, Introduction to non-linear analysis. **Dynamic analysis** - Free vibration of damped and undamped Single Degree Freedom systems, response of SDF to harmonic excitations, vibration isolation, force transmissibility and base motion, Response of undamped SDF to short duration impulse, Duhamel integral, time history analysis, integration schemes, Response Spectra, Multiple degree of freedom systems, eigen values and eigen vectors, mode- superposition method, Response to harmonic excitations of MDF systems, Introduction to computer programs for dynamic analysis,	
Reference Books	1. Timoshenko and Goodier - Theory of Elasticity 2. Weaver and Gere - Matrix analysis of framed structures 3. H. C. Martin - Matrix Method of Structural Analysis 4. Clough and Penzien - Dynamics of Structures 5. Mario Paz - Structural Dynamics 6. Bathe and Wilson - Numerical methods in finite element analysis by 7. R.D. Cook, Plesha & Malkus – Concepts in Finite Element Analysis. 8. C.S. Krishnamoorthy – Finite Element Analysis-Theory & Programming.	
Faculty	S.K. Bhattacharyya, A.K. Pandey & S.K. Panigrahi	

ENG(CBRI) 1-145	Research Methodology for Engineers	L-T-P-C 2-0-0-1
Syllabus	Introduction to Research Methodology – Research terminology and the scientific methods; Designing and implementing a research project, Types of research; Measurements in research, Communicating research results, Case studies Primary and secondary data, Analysis of data Quantitative analysis: Bivariate and Multivariate Analysis, Least square method, Curve fitting, Fitting of linear correlation and regression, Multivariate analysis, Principle component analysis, Discriminant analysis, Factor analysis and their applications Professional ethics, Ethics in Research, Plagiarism, Nuremberg code etc. Communication Skills, presentation, Inter-personal communication.	
Reference Books	1. Gupta, Hira, Operations Research, S. Chand & Company, 1987. 2. Mohan C, K. Deep, Optimization Technique, New Age International, 2009. 3. Sharma J.K., Operation Research -Theory and Applications, Mcmillan Publishers India, 2008 4. Hamdy. A. Taha, Operations Research, PHI, New Delhi. 5. S.S.Rao, Optimization Techniques, New Age International, New Delhi. 6. Gillett, Introduction to operations Research, McGraw Hill, New Delhi 7. Morse Phillip Mccord, Methods of Operational Research, Dover Pub. 8. Sobel methew J., Stochastic Optimization, Dover Pub.	
Faculty	S.K. Bhattacharyya, A. Ghosh & Abha Mittal	

ENG(CBRI) 1-147	Laboratory - I Geotechnical Engineering, Materials and Environmental science and Technology	L-T-P-C 0-0-4-2
Syllabus	**Geotechnical Laboratory Work:** **Laboratory Soil Investigation:** Evaluation of physical properties of soils - Evaluation of compressibility characteristics of soils - Evaluation of shear strength parameters of soils - Evaluation of hydraulic properties of soils **Field Soil Investigation:** The syllabus deals with evaluation of design parameters of soils based on field testing. **Materials and Environmental Science and Technology Laboratory Work:** Physical and Chemical testing of cement, Physico – chemical testing of water for construction purposes – Physical, chemical and engineering properties of building materials / components – Instrumental methods for analysis of building materials (AAS, SEM etc), Air pollution test, water quality test.	
Faculty	B. Singh, A.K. Sharma I, S.K. Jain & L.P. Singh	

Core Courses SEMESTER II

ENG(CBRI) 1-136	Design of Building Structures	L-T-P-C 3-0-0-3
Syllabus	Introduction – Design loads with special reference to earthquake and wind loads - load combinations - Design requirements – materials of construction commonly used for buildings. Wind effects on buildings – Codal provisions – Criteria for wind resistant design of buildings – Concept of wind engineering with reference to aerodynamics of bluff bodies, vortex shedding. Concept of earthquake resistant design of buildings – linear analysis – non-linear analysis – Codal provisions and methods. Introduction to plastic analysis in steel structures – Concepts of LRFD design – Codal provisions – Design concepts of tall building system. Computer applications in the design.	
Reference Books	1. Reinforced Concrete Design, 2nd Edition, by S.Unnikrishna Pillai and Devdas Menon, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003. 2. Reinforced Concrete Limit State Design, 6th Edition, by Ashok K. Jain, Nem Chand & Bros, Roorkee, 2002. 3. Advanced Reinforced Concrete Design, by P.C.Varghese, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001 4. Design of Steel Structures, by A.S. Arya and Ajmani. 5. Plastic design of structures by Horne. 6. Plastic design of structures by B.G. Neal.	
Faculty	A.K. Mittal, R. Deolia & Ajay Chaurasia	

ENG(CBRI) 1-138	Disaster Resistant Building System - I	L-T-P-C 3-0-0-3
Syllabus	**Earthquake Resistant System:** **Introduction to geotechnical earthquake engineering -** dynamic properties of soils and its evaluation, liquefaction hazard evaluations and remedial measures, geotechnical failure of foundations during earthquake, provision of IS 1893 and IS 13920 **Seismic bearing capacity of shallow foundations** – design requirements – ultimate bearing capacity theory under earthquake loading – seismic settlement **Seismic analysis of pile foundation** - normal/liquefiable soils – theories of pile failure in areas of seismic liquefaction – methods of analysis – design concepts of piles under earthquake loading **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 – Fire resistance of building elements – Smoke movement and control – Fire dynamics and modelling – Fire detection – Fire extinguishment.	
Reference Books	1. Bhattacharya S. (eds): (2007), 'Design of foundation in seismic areas: Principles and some applications', Published by NICEE [National Centre for Earthquake Engineering (India)]. ISBN: 81-904190-1-3. 2. Day R. W.(2002), 'Geotechnical Earthquake Engineering', handbook , McGraw – Hill, New York 3. Gopal Madabhushi, Jonathan Knappett, Stuart Haigh, (2010), Design of Pile Foundations in Liquefiable Soils', Imperial College Press, London WC2H 9HE. 4. Prakash, S., (1981), 'Soil dynamics', McGraw Hill, New York 5. Steven L. Kramer (1996), 'Geotechnical Earthquake Engineering', Prentice Hall, New Delhi	
Faculty	A. Ghosh, S. Karthigeyan & Suvir Singh	

Elective Courses

ENG(CBRI) 1-140	Concrete Technology	L-T-P-C 3-0-0-3
Syllabus	**Advances in Concrete -** Characterization of ingredients, Philosophy of concrete mix proportioning, Concrete mix proportioning with mineral & chemical admixtures, Science of concrete including mixing, transporting, placing and curing, Properties of fresh and hardened concrete, Micro structures, Non destructive & in-place evaluation of concrete, New materials in concrete. **Durability of concrete -** Porosity, Pore size distribution, Transition zone, w/c ratio and permeability, Carbonation and chloride penetration, Corrosion, Sulphate attack, Alkali- silica reaction, Other chemical attacks, Protection measures against corrosion. **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. **Concrete Technology -** Sustainable & durable construction with concrete **Quality Control -** Quality control & quality assurance during construction.	
Reference Books	1. M. Neville, Properties of concrete, John Wiley & Sons Inc, 4th Edition, 1996. 2. P.K. Mehta and Paulo J. M. Monteiro, "Concrete: Microstructure, properties and Materials", McGraw- Hill, 2005. 3. M. Neville & J. J. Brooks "Concrete Technology", 4th Impression, Pearsons Education Ltd,2009. 4. J.H. Bungey, S. G. Millard & M. G. Grantham, Testing of concrete in Structures, 4th edition,Taylor & Francis, London & New York, 2006.	
Faculty	B.K. Rao, S.R. Karade & S.K. Singh	

ENG(CBRI) 1-142	Planning, Regulations & Management of Buildings	L-T-P-C 3-0-0-3
Syllabus	**Introduction to Building Projects** - Overview of various building projects in India vis – a vis national programmes, modes of public – private participation and innovative approaches for fiscal mibilisation and financing. **Project** - formulation, appraisal and evaluation – Feasibility studies, preparation of Detailed Project Reports (DPRs). **Project Management Issues** - Planning, monitoring and scheduling of the project activities and application of Information technology tools, project completion, compliance and closure. **Tender** - Documents and selection process, contract correspondence, formulation of claims, variations and extensions, dispute resolution, reconciliation and arbitration. **Legal Issues** - Rules, Regulations and land acquisition acts, relevant contracts, rehabilitation and resettlement issues. **Case studies** - Urban housing and other building projects	
Reference Books	1. Adedeji B. Badiru, STEP Project Management: Guide for science, technology and engineering projects, CPC press, Taylor and Francis Group, USA, 2009. 2. World Bank, Procurement documents related infrastructure projects, www.worldbank.org 3. Related Documents – Planning Commission, MoEF, MoRT&H, MoUD, NHAI, NRRDA, etc.	
Faculty	Ashok Kumar	

ENG(CBRI) 1-144	Industrialized Building Systems	L-T-P-C 3-0-0-3
Syllabus	**Introduction** – Generic classification of prefabricated and industrialized building systems, advantages and disadvantages of IBS, industrialization for sustainable construction. **Standardization** – Introduction to Modular Coordination, Standardization, rationalization and systematization, codal provisions for modular coordination. **Building Systems -** Criteria for Selection, Sub-structure structural systems, horizontal and vertical Systems, open and closed Building Systems. **Strategies for Industrialization -** User friendly building components, production strategies, emerging concepts for future prefabrication. **Prefabricated Systems for Building Envelopes -** Generic forms of construction, façade technologies, building components and jointing details. **Case studies and design -** Case studies of prefab technologies and design ideas for IBS.	
Reference Books	1. Frederick S. Merritt, and James Ambrose; "Building Engineering and Systems Design" (Second Edition); a Text Book Published by Van Nostrand Reinhold, New York (1990). 2. ASG Bruggeling, GF Huyghe; "Prefabrication with Concrete"; A Text Book Published by AA Balkema, PO Box 1675, 3000 BR Rotterdam, Netherlands. 3. F. (Eph.) BLJUGER; "Design of Precast Concrete Structures"; A Text Book Published by John Wiley & Sons (1988). 4. Kim S. Elliott; "Multi Storey Precast Concrete Framed Structures" A Text Book Published by Blackwell Science Ltd (1996). 5. Prestressed Concrete Institute (PCI), Chicago, Manual on Design and Typical Details of Connections for Precast and Prestressed Concrete second edition (1988). 6. National Building Code - 2005. 7. IS Codes on Modular Coordination	
Faculty	Ashok Kumar & S.P. Agarwal	

ENG(CBRI) 1-146	Repair, Rehabilitation & Retrofitting of Structures	L-T-P-C 3-0-0-3
Syllabus	**Condition Assessment:-** Appraisal of structures, Types of distresses in structures, Distress diagnosis, In-place assessment, Data collection, Evaluation of buildings based on demand-capacity method, Irregularities & inconsistencies in construction, Residual life assessment. **Innovative Repair Materials:-** Criteria for repair, Rehabilitation & retrofitting of structures, Types of repair materials, structural characteristics & its behaviour, Testing & evaluation of repair materials & system. **Repair Techniques:-** Types of rehabilitation & strengthening techniques & its applications, Strategies for strengthening, Philosophy and design of strengthening, Grouting, Sprayed concrete, Steel jacketing, Micro-concreting, FRP wrapping, Codal provisions, Introduction to performance based strengthening strategies, Technical specifications, Quantifications of repair materials. **Quality Assurance and Control:-** Introduction, Check & balances during repair & strengthening **Case Studies:**- Buildings & Heritage structures	
Reference Books	1. H.V.S. GangaRao, Navendra Taly & P.V. Vijay "Reinforced Concrete Design with FRP composites", 1st edition, 2007, CRC Press, Tylor & Francis group, USA. 2. A. Chakrabarti, D. Menon & A Sengupta, "Hand book on Retrofitting of Structures-Principles & Applications, 1st edition,2010, Narosa Publishing House, New Delhi 3. J.H. Bungey, S. G. Millard & M. G. Grantham, Testing of concrete in Structures, 4th edition, Taylor & Francis, London & New York, 2006. 4. Gajanan M. Sabnis, Avanti C. Shroff & Lawrence F. Kahn "Seismic Rehabilitation of Concrete Structure", 1996, SP-160, American Concrete Institute, Michigan, USA. 5. "Repair and strengthening of concrete structure", FIP ,Thomas Telford, London 6. R.Holland "Appraisal & Repair of Reinforced Concrete", ,The Gromwell Press, Thomas Telford Ltd., London 7. Nader Ghafoori "Innovation in Repair Techniques in Concrete Structures", ASCE publication.	
Faculty	S.K. Bhattacharyya, S.K. Singh & Ajay Chaurasia	

ENG(CBRI) 1-148	Environmental Impact Assessment	L-T-P-C 3-0-0-3
Syllabus	**Introduction and Scope** - EIA and Sustainable Development, Environmental Impacts of Infrastructure Projects, Impacts of Development Activities, Planning and Management of Impacts Studies. **Environmental Clearance Process in India** - Salient Features of EIA Notification. **Impact assessment** - Assessment of Impact of infrastructural development on air, surface & sub-surface water, soil, noise, etc. - Environmental Assessment Methods and Techniques, Prediction Technique for Quality of Environment Attributes, Evaluation Methods. **Environmental Quality Standards** - Regulations and Legislations **Control measures** - Air Pollution and Noise Pollution control, Preparation of Environmental Management Plan - Carrying capacity and Assimilation Capacity Studies for Sustainable Development **Case Studies** – Green Buildings	
Reference Books	1. David C.Wooten & J.G.Ran Environmental Impact Analysis Hand Books Pub. McGraw – Hill ISBN – 100070512175 (1979). 2. Canter L.W., Environmental Impact Assessment, McGraw-Hill, 1997 3. Betty Bowers Marriott, Environmental Impact Assessment A Practical Guide McGraw-Hill Professional, 1997 4. Peter Morris & Riki Therivel, Methods of Environmental Impact Assessment, Routtedge, 2001. 5. Denver Tolliver, Highway Impact Assessment, Greenwood Publishing Group, 1993 6. R.K.Jain, L.V.G.S. Stacey, H.E. Balbach, Environmental Assessment McGrew-Hill Professional, 2001. 7. Relevant IRC & CPCB Code of Practices / Guidelines 8. CPCB (2006) Pollution Control Acts, Rules and Notifications issued there under Pollution Control Law Series' PCLS/02/2006 Central Pollution Control Board, Delhi.	
Faculty	A.K. Minocha	

ENG(CBRI) 1-150	Sustainable Design and Energy Efficient Building Systems	L-T-P-C 3-0-0-3
Syllabus	**Introduction -** Overview of sustainable design and energy efficient building systems, Comprehensive understanding of sustainable design principles. **Challenges driving the need for Sustainable Design -** Low carbon building technologies, Climate factors for buildings design, Thermal comfort and insulation. **Building Performance Assessment Tools - Green** building rating systems, Energy Conservation Building Code, Application of performance assessment tools. **Insulation and Heat Transfer -** Low energy building materials, Heat repellent and insulating materials, Heat transfer through building elements. **Case Studies - Integrated** design process, Green / Sustainable design projects.	
Reference Books	1. Godfrey Boyle, Renewable Energy, Oxford University Press, 2004, Reprint 2010. 2. Sharma I C, The Climatic Data Handbook, Tata Mc Graw Hill Pub. Co. Ltd., 1993. 3. Givoni B, Man Climate & Architecture, Elsevier, 1969 4. Arvind Krishnan & et al., Climate Responsive Architecture – A Design Handbook for Energy Efficient Buildings, Tata Mc Graw Hill Pub. Co. Ltd. 5. Gupta C P, Prakesh Rajendra, Engineering Heat Transfer, Nem Chand & Brothers-Roorkee, 1979	
Faculty	R.K. Garg & Ashok Kumar	

ENG(CBRI) 1-152	Construction, Planning & Management	L-T-P-C 3-0-0-3
Syllabus	**Introduction** - RCC and masonry system, pre-engineered and industrialized building system and its relevance, planning and design of modules, construction methodology, construction techniques, large panel system etc., design of joints for transfer of loads in pre-engineered structural system, transportation of materials and structural components in vertical and horizontal direction, different types of construction equipment. **Planning** - Fundamentals for construction planning, project life cycle, project proposal, project selection. **Construction project management** - Network scheduling, critical path method (CPM), project evaluation and review technique (PERT), planning and scheduling of activity network, cost – time trade off, linear programming, PERT / Cost accounting. Scheduling with limited resources, resource planning, resource allocation, project schedule compression, generalized activity network. Estimation of project cost, earned value analysis, monitoring project progress, project appraisal and selection, recent trends in project management.	
Reference Books	1. The Construction of Buildings - Parts 1-4 - R. Barry. 2. Construction Management – Himadri Roy & B. Sengupta.	
Faculty	S.K. Bhattacharyya	

ENG(CBRI) 1-154	Fire Protection Engineering	L-T-P-C 3-0-0-3
Syllabus	Introduction to fire safety engineering – Heat transfer mechanisms in fire & build up of untenability conditions – Combustion flammability and retardency, its application – Flames / fire plumes – Burning behaviour of materials - Active and Passive fire protection	
Reference Books	1. The Chemistry & Uses of Fire Retardants By J W Lyone - Wiely Interscience 2. Fire Resistant Designs By T H Harmathy 3. Fire Suppression & Detection System By John L Bryan - Macmillan 4. Combustion Fundamentals of Fire By Geoffrey Cox - Academic Press 5. Introduction to Fire Dynamics By D D Drysdale	
Faculty	Sunil Sharma & Suvir Singh	

ENG(CBRI) 1-156	Environmental Engineering & Management	L-T-P-C 3-0-0-3
Syllabus	**Water and Wastewater Engineering:** Water and wastewater quality, water and wastewater treatment plants and systems: physical, chemical and biological systems, primary, secondary and tertiary treatment. Industrial wastewater treatment: characteristics of industrial wastewater, treatment levels and available technologies. **Air Quality and Modelling:** Sources and classification of atmospheric pollutants, indoor and outdoor air pollutants, healthand ecological impacts, meteorology: influence of solar radiation and wind fields, lapse rate andstability conditions, characteristics of stack plumes, Dispersion and deposition modeling of atmospheric pollutants: Eddy and Gaussian diffusion models, techniques. Characteristics ofvarious air pollutant particulates, health and nuisance/aesthetic considerations (PM2.5 and PM10) and gaseous their behaviour in the atmosphere, monitoring, Control of particulates: collection mechanisms and efficiencies. **Solid Waste Management:** Solid waste generation rate, sources, characteristics, management options of the solid waste- collection, recycling, treatment and disposal techniques. **Emerging Technologies in Environmental Management** Current trends and emerging technologies, contemporary issues.	
Reference Books	1. Environmental Engineering, Howard S. Peavy, Donald R. Rowe, McGraw Hill. 2. Environmental Engineering, S. K. Garg, Khanna Publishers 3. Wastewater engineering, treatment, disposal and reuse, Metcalf and Eddy, McGraw Hill. 4. Air Pollution, A. C. Stern, Vol I to VIII, Academic Press 5. Air pollution, Rao M.N. & Rao H.V.N., Tata McGraw hill 6. Solid waste management in developing countries – A.D. Bhide, B.B.Sudresan, New Delhi: Indian National Scientific Documentation Centre, 1983	
Faculty	Ibrahim Sohel & Soumitra Maiti	

ENG(CBRI) 1-158	Advanced Seismology	L-T-P-C 3-0-0-3
Syllabus	Introduction, Science of Earthquakes, Types and causes, Earthquake Parameters, Seismic Waves, Magnitude & Intensity, Earthquake Source Mechanism, Seismic Instrumentation, Seismicity & Seismic Zoning Map, Indian Earthquake Scenario, Strong Motion Seismology, Site Response Studies, Seismic Attenuation, Source and Path effect, Seismic Hazard Analysis, Seismic Risk and its estimation, Seismic Micro-zonation, Earthquake Prediction Studies, Seismic Alert Systems	
Reference Books	1. Engineering Seismology by P.N. Agrawal. Published by Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi 2. Earthquakes by Bruce A. Bolt. Published by W.H. Freeman & Company. ISBN – 978-0716722366. 39.63$ 3. Quantitative Seismology; Theorey & Methods, by Aki, K. and Paul G. Richards. Published by W.H. Freeman & Company, San Fransisco, Vol. 1 & 2. 4. Geotechnical Earthquake Engineering by Ikuo Towhata. Published by Springer Berlin Heidelberg. ISBN – 978-3-540-35782-7. 69.	
Faculty	P K S Chauhan & Abha Mittal	

ENG(CBRI) 1-160	Engineering of Problematic Soil	L-T-P-C 3-0-0-3
Syllabus	**Introduction**: Various problematic soils, Problems, Need of improvement, Difference between improvement and modification. **Soft Soil**: Introduction, Problems, Various improvement techniques –Preloading, Vertical drain, Stone column, Compaction ,Chemical stabilization ,Ground Freezing, Electro Osmosis **Expansive Soil**: Introduction, Clay mineralogy, Problems, determination of swell pressure, Consequence, Improvement of expansive soils, Foundation techniques, IS codal provision. **Loose Cohesionless Soil**- Introduction, Problems, Various improvement techniques, Dynamic Compaction, Blasting, Vibrofloatation, Chemical stabilization, Grouting. **Organic Soil**-Introduction, Problems, Strength, Secondary settlement, Improvement techniques, Foundation techniques. **Contaminated Soil-**Introduction, Effect of contamination, Contamination transportation, Detection of Polluted zone, Remediation.	
Reference Books	1. Ground Improvement Techniques by Dr. P.Purushothama Raj, Laxmi publication (p) ltd. New Delhi. 2. Behavior of Saturated Expansive Soil & Control Methods by R. K. Katti, A.A. Balkema publishers 3. Ground Improvement by M.P. Moseley & K. Krisch, Spon Press, Taylor and Francis Group. 4. Soft Clay Engineering by E.W. Brand & R.P.Brener, Elesevier Scientific Publishing Company 5. Soil Mechanics in Engineering Practices by K.Terzaghi, R.B. Peck & Mesri, A wiley Interscience Publication 6. Basic and Applied Soil Mechanics by G. Ranjan & A.S. Rao, New Age International Publication	
Faculty	A. Ghosh & Manojit Samanta	

ENG(CBRI) 1-162	Optimization Techniques	L-T-P-C 3-0-0-3
Syllabus	Different types of optimization problems, General form of linear programming problem graphical solution - Cannonical form of LPP, Simplex method, basic feasible solution, Big M method, degeneracy, revised Simplex Method - Duality in linear programming , application of duality theory, post optimality or sensitivity analysis - Lagrangian function and saddle point, Kuhn Tucker conditions, primal and dual problem - Integer LPP, cutting plane method, branch and bound method, integer non-linear programming - Pseudo-random numbers, random variables, Multivariate distributions, Poisson process, Gaussain process, point process, uses of simulations - Introduction to neural network and genetic algorithm etc. - Stochastic Programming	
Reference Books	1. Gupta, Hira, Operations Research, S. Chand & Company, 1987. 2. Mohan C, K. Deep, Optimization Technique, New Age International, 2009. 3. Sharma J.K., Operation Research -Theory and Applications, Mcmillan Publishers India, 2008 4. Hamdy. A. Taha, Operations Research, PHI, New Delhi. 5. S.S.Rao, Optimization Techniques, New Age International, New Delhi. 6. Gillett, Introduction to operations Research, McGraw Hill, New Delhi 7. Morse Phillip Mccord, Methods of Operational Research, Dover Pub. 8. Sobel methew J., Stochastic Optimization, Dover Pub.	
Faculty	A. Ghosh & S.K. Bhattacharyya	

ENG(CBRI) 1-164	Deep Excavation	L-T-P-C 3-0-0-3
Syllabus	Introduction to the analysis and design of excavation Excavation methods and lateral supporting systems – retaining walls – strutting systems – factors influencing on the selection of the retaining strut system – case history. Lateral earth pressure – Rankine's and Coulomb's earth pressure theory – earth pressure for design of excavation Stability analysis – introduction – free and fixed earth support method – shear failure of strutted walls – push in – basal heave - upheaval – sand boiling Stress and deformation analysis of excavation: simplified method – beam on elastic foundation method – finite element method Design of excavation supporting systems; Introduction – design methods and factor of safety – retaining wall – structural components in braced excavations – strut systems – anchor systems – tests of anchors	
Reference Books	1. Deep Excavation Theory and Practice by Chang – Yu Ou, Taylor & Francis Group, London, UK, 2006. 2. An Introduction to Geotechnical Engineering by Holtz, R.D. and Kovaces, W.D., Prentice – Hall, Inc., Englewood Cliffs, NJ, 1981. 3. Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, 1967. 4. Foundation Engineering by Peck, R. B., Hanson, W.E., and Thornburn, T.H., John Wiley & Sons, New York, 1977. 5. Engineering Principles of Ground Modification by Hausman, M. R., McGraw – Hill Publishing Company, New York, 1990. 6. Foundation Analysis and Design by Bowles, J. E. , 4th Ed. McGraw – Hill Book Company, New York, USA, 1988.	
Faculty	S.Karthigeyan	

ENG(CBRI) 2-138	Health Monitoring of Building Structures	L-T-P-C 3-0-0-3
Syllabus	Introduction – Health monitoring systems of building structures - Numerical modelling– Use of sensors – Data acquisition techniques – Data Processing – Diagnostic techniques – Wireless sensor network – Rehabilitation techniques.	
Reference Books	1. Victor Giurgiutiu – structural health monitoring with piezoelectric wafer active sensors. 2. Douglas E Adams – Health monitoring of structural materials and components 3. Fu-kuochang – Structural health monitoring from system interpretation to autonomous systems.	
Faculty	S.K. Bhattacharyya & Ajay Chaurasia	

ENG(CBRI) 3-136	Tall Buildings & Structures	L-T-P-C 3-0-0-3
Syllabus	Introduction – Tall building systems – Analysis Methodology of tall building frames – Different types of loads – Lateral load analysis – multibay frames; Shear walls – types – analysis – Coupled frames – Frame with shear wall; Principles of 3-D analysis of tall buildings; Perforated cores – types – Analysis – 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.	
Reference Books	1. Structures – E. Schodex 2. Tall Buildings – B.S. Taranath 3. Tall Chimneys – C.S. Manohar 4. Theory of Elastic Stability – Timoshangeo & Gere	
Faculty	S.K. Bhattacharyya & A.K. Mittal	

ENG(CBRI) 3-138	Behaviour of Metal Structures	L-T-P-C 3-0-0-3
Syllabus	Introduction – Stability of frames, plates – Lateral buckling of beam – Combined bending and axial-combined bending & torsion; Buckling of thin elements – Torsional buckling of thin walled structures and open sections – Column – Strength curves – Buckling and post-buckling strength of plate elements with special reference to Codal provisions – Behaviour of light gauge steel structures; Prestressing in steel structures.	
Reference Books	1. Behaviour of Steel Structures – Salmon & Johnson 2. Theory of Elastic Stability - Timoshangeo & Gere 3. Elastic Stability – Ashwini Kumar 4. Design of Light gauge Structures – Yu 5. Design of Metal Structures – K. Mukhanov 6. Design of Welded Structures – O.E. Blodgeth	
Faculty	S.K. Bhattacharyya, A.K. Mittal & A.K. Pandey	

ENG(CBRI) 3-140	Rock Mechanics	L-T-P-C 3-0-0-3
Syllabus	**Introduction to rock mechanics** **Rocks, rock structures and their importance**: Rocks (Igneous, sedimentary, metamorphic) & rock masses; Joints & discontinuities; Folds & faults; Effect of discontinuities on stability using stereographic approach **Surface and subsurface investigations:** Geological and geophysical investigations **Engineering rock mass classifications & their application**: Terzaghi's rock load concept; RMR; Q; GSI **Physico-mechanical properties of rocks**: Important physico-mechanical properties; Effect of temperature on rock strength; Dynamic properties **Stresses in elastic and plastic ground conditions**: In situ stresses; Induced stresses after excavation; Stress variation around horizontal circular opening in elastic & plastic ground conditions **Excavation Methods**: Drill & blast methods for surface and underground; Tunnel boring machine (TBM) **Support design and instrumentation in tunnels and slopes**: Analytical and empirical approaches in brief; GRC & SRC; NATM; Support types; Design considerations under dynamic conditions; Instrumentation **Problems and their remedies in rock engineering**: Stress problems (Squeezing and rock-burst); Swelling and water pressure **Application of rock mechanics**: Traffic tunnels; Hydro-electric tunnels; Building/ dam foundations on rock; Underground civic facilities; Underground defence shelters, storage of petroleum and nuclear waste repository, etc.	
Reference Books	1. Rock Mass Classification – A Practical Approach in Civil Engineering, B. Singh, R. K. Goel, Elsevier Science Ltd., U.K. 2. Software for Engineering Control of Landslide and Tunnelling Hazards, B. Singh, R. K. Goel, Balkema/ Swets & Zeitlinger, Netherlands 3. Tunnelling in Weak Rocks, B. Singh, R. K. Goel, Elsevier Ltd., U.K. 4. Rock Mechanics for Engineers, B.P. Verma, Khanna Publishers, Delhi	
Faculty	R.K. Goel & V.V.R. Prasad	

ENG(CBRI) 3-142	Landslide Disaster Mitigation	L-T-P-C 3-0-0-3
Syllabus	Introduction - Landslide Types and processes - Landslide causes - Application of Remote Sensing and GIS in Landslide studies: Spatial data acquisition and spatial operations, Digital Elevation Modeling & Surface analysis, Thematic mapping, Spatial analysis and model development - Landslide Hazard and Risk Assessment: Concept & Techniques, Case Studies - Landslide Investigations: Geological, geophysical & geotechnical - Landslide Instrumentation: Surface & sub-surface monitoring - Slope Stability Analysis: Rock & soil slopes - SMR & Slope Stability Assessment - Landslide Control Measures: Types of measures & design - Landslide case studies	
Reference Books	1. Landslides – Risk Analysis and Sustainable Disaster Management by Sassa 2005; ISBN:978-3-540-28664-6; Springer Publishers 2. Landslides – Investigation and Mitigation, Ed: Turner and Schuster, 1996 3. Rock Slope Engineering by Hoek & Bray 4. Geotechnical Slope Analysis by Robin Chowdhury; Taylor & Fransis, 5. Burrough, P.A. and McDonnell, R.A., "Principles of Geographic Information System", Oxford University Press. 6. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2002.	
Faculty	S. Sarkar & D.P. Kanungo	

ENG(CBRI) 1-166	Laboratory - II Structural Engineering & Fire Engineering	L-T-P-C 0-0-4-2
Syllabus	**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.	
Faculty	S.K. Singh & A.A. Ansari	

Core Courses

SEMESTER III

ENG(CBRI) 2-136	Disaster Resistant Building System II	L-T-P-C 3-0-0-3
Syllabus	**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.	
Reference Books	1. Landslides – Risk Analysis and Sustainable Disaster Management by Sassa 2005; ISBN:978-3-540-28664-6; Springer Publishers 2. Landslides – Investigation and Mitigation, Ed: Turner and Schuster, 1996 3. Rock Slope Engineering by Hoek & Bray 4. Geotechnical Slope Analysis by Robin Chowdhury; Taylor & Fransis, 5. Dynamics of Structures: Theory and application to Earthquake Engineering by Anil K. Chopra, Pearson Education(Singapore) PTE.LTD 6. Seismic Design of Reinforced Concrete and Masonry Buildings by T Pauley and MJN Priestley, John Wiley and Sons inc. New York, Australia. 7. Earthquake Risk Reduction, John Wiley & Sons Limited, by David J. Dowrick, 2003	
Faculty	S. Sarkar, D.P. Kanungo, A.K. Mittal & R. Deolia	

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CSIR-CEERI

Advanced Electronic Systems

MTech Programme : Semester-wise Scheme : Advanced Electronic Systems

Semester-I

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-208	System Design for Process Control Applications	3-0-0-3
ENG(CEERI) : 2-209	System Modeling and Design Languages	3-0-0-3
ENG(CEERI) : 2-210	Intelligent Sensor Systems	3-0-0-3
ENG(CEERI) : 2-215	Lab: Process Control Applications	0-0-4-2
ENG(CEERI) : 2-216	Lab: System Modeling	0-0-4-2
ENG(CEERI) : 2-217	Lab: Intelligent Sensor Systems	0-0-4-2
ENG(CEERI) : 1-206	Technical Communications	2-0-0-2

Semester-II

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-211	Real-time Embedded System Design	3-0-0-3
ENG(CEERI) : 2-212	Advanced Signal and Image Processing	3-0-0-3
ENG(CEERI) : 2-213	Power Electronics and AC/DC Drives	3-0-0-3
ENG(CEERI) : 2-218	Lab: Real-time Embedded System Design	0-0-4-2
ENG(CEERI) : 2-219	Lab: Advanced Signal and Image Processing	0-0-4-2
ENG(CEERI) : 2-220	Lab: Power Electronics and AC/DC Drives	0-0-4-2
ENG(CEERI) : 2-206	Project Management	2-0-0-2

Semester-III

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-002	Advanced Self-study on Special Topic	0-2-4-4
ENG(CEERI) : 2-098	MTech Dissertation-I	0-7-14-14

Semester-IV

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-099	MTech Dissertation-II	0-9-18-18

MTech Programme : Brief Course Descriptions : Advanced Electronic Systems

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) : 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) : 3-002 : 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.

List of Faculty Members : Advanced Electronic Systems

S. No.	Name	Designation	Discipline
1.	Dr. Chandra Shekhar	Director	Microelectronics/VLSI Design
2.	Sh. Rahul Varma	Chief Scientist	Power Electronics and AC/DC Drives
3.	Sh. Raj Singh	Chief Scientist	Microelectronics/VLSI Design
4.	Dr. P. Bhanu Prasad	Chief Scientist	Electronic Instrumentation
5.	Dr. J. L. Raheja	Sr. Princ. Sc.	Image Processing
6.	Dr. S. S. Sadistap	Sr. Princ. Sc.	Electronic Instrumentation
7.	Dr. P. C. Panchariya	Princ. Sc.	Electronic Instrumentation
8.	Dr. A. Karmakar	Princ. Sc.	Signal Processing/VLSI Design
9.	Dr. K. Solomon Raju	Sr. Scientist	Digital Systems Engineering
10.	Sh. A. K. Dhakar	Scientist	Power Electronics and AC/DC Drives
11.	Sh. H. D. Sharma	Scientist	Mechatronics/Embedded Systems
12.	Sh. Pramod Tanwar	Scientist	Digital Systems/Embedded Systems
13.	Dr. B. A. Botre	Scientist	Instrumentation/Embedded Systems
14.	Sh. Santosh Kumar	Scientist	Electronic Instrumentation
15.	Dr. A. S. V. Sarma	Chief Scientist	Electronic Instrumentation
16.	Dr. A. Gopal	Sr. Princ. Sc.	Electronic Instrumentation
17.	Dr. R. Govindraj	Princ. Sc.	Electronic Instrumentation

CSIR-CEERI

Advanced Semiconductor Electronics

MTech Programme : Semester-wise Scheme : Advanced Semiconductor Electronics

Semester-I

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-221	Physics of Semiconductor Materials and Devices	4-0-0-4
ENG(CEERI) : 2-222	Unit Processes in Semiconductor Technologies	3-0-0-3
ENG(CEERI) : 2-223	CMOS Digital VLSI Design	3-0-0-3
ENG(CEERI) : 2-225	Lab: Semiconductor Processing Technologies	0-0-4-2
ENG (CEERI) : 2-226	Lab: CMOS-based Physical Design	0-0-4-2
ENG(CEERI) : 1-206	Technical Communications	2-0-0-2

Semester-II

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-224	Characterization Techniques for Semiconductor Materials, Technologies and Devices	3-0-0-3
ENG(CEERI) : 2-227	Lab: Characterization and Measurement Techniques	0-0-4-2
ENG(CEERI) : 3-211 / 3-213 / 3-215 / 3-217	Elective-I	0-0-4-2
ENG(CEERI) : 3-212 / 3-214 / 3-216 / 3-218	Elective-II	3-0-0-3
ENG(CEERI) : 3-221 / 3-223 / 3-225 / 3-227	Lab/Seminar: Elective-I Related	0-0-4-2
ENG(CEERI) : 3-222 / 3-224 / 2-228 / 3-228	Lab/Seminar: Elective-II Related	0-0-4-2
ENG(CEERI) : 2-206	Project Management	2-0-0-2

MEMS and Microsensors (Elective-I and Elective-II)

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-211	MEMS Technology, LTCC and Packaging	3-0-0-3
ENG(CEERI) : 3-212	Physics and Design of MEMS and Microsensors	3-0-0-3
ENG(CEERI) : 3-221	Lab: MEMS Technology, LTCC and Packaging	0-0-4-2
ENG(CEERI) : 3-222	Lab: Design of MEMS and Microsensors	0-0-4-2

Nanoelectronics (Elective-I and Elective-II)

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-213	Nanoelectronic Devices and Technologies	3-0-0-3
ENG(CEERI) : 3-214	Advanced VLSI Technologies and Devices	3-0-0-3
ENG(CEERI) : 3-223	Lab: Nanoelectronic Technologies	0-0-4-2
ENG(CEERI) : 3-224	Lab: Study and Seminar on Advanced VLSI Technologies	0-0-4-2

VLSI Design (Elective-I and Elective-II)

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-215	CMOS Analog Design	3-0-0-3
ENG(CEERI) : 3-216	Advanced VLSI System Architectures	3-0-0-3
ENG(CEERI) : 3-225	Lab: CMOS Analog Design	0-0-4-2
ENG(CEERI) : 2-228	Lab: HDL-based Digital Design	0-0-4-2

Optoelectronics and Photonics (Elective-I and Elective-II)

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-217	Optoelectronic Materials, Devices and Technologies	3-0-0-3
ENG(CEERI) : 3-218	Photonic Materials, Devices and Technologies	3-0-0-3
ENG(CEERI) : 3-226	Lab: Optoelectronic Devices and Technologies	0-0-4-2
ENG(CEERI) : 3-227	Lab: Photonic Devices and Technologies	0-0-4-2

Semester-III

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-002	Advanced Self-study on Special Topic	0-2-4-4
ENG(CEERI) : 2-098	MTech Dissertation-I	0-7-14-14

Semester-IV

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-099	MTech Dissertation-II	0-9-18-18

MTech Programme : Brief Course Descriptions : Advanced Semiconductor Electronics

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) : 2-221 : 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) : 3-002 : 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.

MTech Programme : List of Faculty Members : Advanced Semiconductor Electronics

S. No.	Name	Designation	Discipline
1.	Dr. Chandra Shekhar	Director	Microelectronics/VLSI Design
2.	Sh. Raj Singh	Chief Scientist	Microelectronics/VLSI Design
3.	Dr. A. S. Mandal	Sr. Princ. Sc.	Microelectronics/VLSI Design
4.	Dr. S. C. Bose	Sr. Princ. Sc.	Microelectronics/VLSI Design
5.	Dr. A. Karmakar	Princ. Sc.	Microelectronics/VLSI Design
6.	Sh. Ravi Saini	Scientist	Microelectronics/Digital Design
7.	Sh. Anil Kumar Saini	Scientist	Microelectronics/Analog Design
8.	Sh. Jai Gopal Pandey	Scientist	Microelectronics/Digital Design
9.	Dr. V. K. Khanna	Chief Scientist	MEMS/IC Technology
10.	Sh. B. D. Pant	Chief Scientist	MEMS Technology
11.	Dr. Ram Gopal	Sr. Princ. Sc.	MEMS Technology/Devices
12.	Dr. K. J. Rangra	Sr. Princ. Sc.	MEMS Devices/Design
13.	Dr. Ajay Agarwal	Princ. Sc.	MEMS Technology/Devices
14.	Dr. Rishi Sharma	Scientist	MEMS Technology/Devices
15.	Dr. P. K. Khanna	Sr. Princ. Sc.	LTCC Technology/Packaging
16.	Dr. Nikhil Suri	Scientist	LTCC Technology
17.	Dr. J. Akhtar	Chief Scientist	Semiconductor Devices
18.	Sh. Anil Kumar	Chief Scientist	Nanoelectronics Technology
19.	Sh. William Taube	Scientist	Nanoelectronics/Nanodevices
20.	Dr. G. Eranna	Sr. Princ. Sc.	IC Technology
21.	Sh. Jitendra Singh	Scientist	IC Technology/Devices
22.	Dr. C. Dhanvantri	Sr. Princ. Sc.	Optoelectronics/Photonics
23.	Dr. Suchandan Pal	Princ. Sc.	Optoelectronics/Photonics
24.	Dr. Bala Pesala	Senior Scientist	Optoelectronics/Photonics

CSIR-CEERI

High Power Microwave Devices and System Engineering

MTech Programme : Semester-wise Scheme :
High Power Microwave Devices and System Engineering

Semester-I

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-231	Electromagnetic Theory and Transmission Lines	4-0-0-4
ENG(CEERI) : 2-232	Microwave Communication	2-0-0-2
ENG(CEERI) : 2-233	Numerical Techniques and CAD of Microwave Tubes	4-0-0-4
ENG(CEERI) : 2-235	Lab: Microwave Components Characterization and Tube Processing Techniques	0-0-6-3
ENG(CEERI) : 1-206	Technical Communications	2-0-0-2

Semester-II

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-231	Slow-wave Devices : Principles and Design	4-0-0-4
ENG(CEERI) : 3-232	Fast-wave Devices : Principles and Design	3-0-0-3
ENG(CEERI) : 2-234	Microwave and Millimeter-wave Tube Technologies	3-0-0-3
ENG(CEERI) : 2-236	Lab: Microwave Devices Characterization and Tube Sub-assembly Fabrication	0-0-6-3
ENG(CEERI) : 3-233	Lab: CAD of Microwave Tubes	0-0-4-2
ENG(CEERI) : 1-206	Project Management	2-0-0-2

Semester-III

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-234	High Power Microwave Devices, Systems and Applications	3-0-0-3
ENG(CEERI) : 3-23x	Elective-I	2-0-0-2
ENG(CEERI) : 2-098	MTech Dissertation-I	0-7-14-14

Elective-I

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 3-235	Electron Emitters and Surface Characterization	2-0-0-2
ENG(CEERI) : 3-236	Plasma-filled Microwave Sources	2-0-0-2
ENG(CEERI) : 3-237	Vacuum Microelectronic Devices	2-0-0-2

Semester-IV

Subject Code	Subject	L-T-P-C
ENG(CEERI) : 2-099	MTech Dissertation-II	0-9-18-18

MTech Programme : Brief Course Descriptions :
High Power Microwave Devices and Systems Engineering

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) : 2-231 : 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) : 3-231 : 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.

MTech Programme : List of Faculty Members :
High Power Microwave Devices and System Engineering

S. No.	Name	Designation	Discipline
1.	Dr. S. N. Joshi	Ex-Scientist G	Microwave Engineering & Tube Technology
2.	Dr. V. Srivastava	Chief Scientist	Microwave Engineering & Tube Technology
3.	Dr. R. S. Raju	Chief Scientist	Microwave Engineering & Tube Technology
4.	Dr. L. M. Joshi	Chief Scientist	Microwave Engineering & Tube Technology
5.	Sh. R. K. Gupta	Chief Scientist	Microwave Engineering & Tube Technology
6.	Dr. V. V. P. Singh	Chief Scientist	Microwave Engineering & Tube Technology
7.	Sh. O. S. Lamba	Sr. Princ. Sc.	Microwave Engineering & Tube Technology
8.	Dr. A. K. Sinha	Sr. Princ. Sc.	Microwave Engineering & Tube Technology
9.	Dr. R. Ranga Rao	Sr. Princ. Sc.	Microwave Engineering & Tube Technology
10.	Dr. R. K. Sharma	Princ. Sc.	Microwave Engineering & Tube Technology
11.	Dr. Sanjay Ghosh	Princ. Sc.	Microwave Engineering & Tube Technology
12.	Dr. Ram Prakash	Princ. Sc.	Plasma Devices
13.	Sh. M. Alaria	Scientist	Microwave Engineering & Tube Technology
14.	Sh. U. N. Pal	Scientist	Plasma Devices
15.	Sh. S. Maurya	Scientist	Microwave Engineering & Tube Technology
16.	Dr. A. Bandhopadhyay	Scientist	Microwave Engineering & Tube Technology
17.	Sh. Vishant	Scientist	Microwave Engineering & Tube Technology

CSIR-CGCRI

Glass and Ceramic Engineering

Course Structure

Semester I			Semester II		
C. No.	**Course Name**	**Credit**	**C. No.**	**Course Name**	**Credit**
ENG-CGCRI -GC 501	Introduction to Materials Engineering	4	ENG - CGCRI - GC 601	Processing of glass and Ceramics	4
ENG-CGCRI -GC 502	Materials characterization– I	4	ENG - CGCRI - GC 602	Materials characterization- II	4
ENG-CGCRI -GC 503	Fundamentals of glass & ceramics	4	Elective (ENG - CGCRI - GE 601 – 604) or (ENG - CGCRI - CE 601 – 604)	--	4
ENG-CGCRI -GC 504	Research methodology and applied statistical techniques for materials engineering	4	Elective (ENG-CGCRI - GE 601 – 604) or (ENG-CGCRI - CE 601 – 604)	--	4
ENG-CGCRI -GC 505	Laboratory safety practice	1	ENG - CGCRI - GC 506	Technical communication	1
	Total Credits	**17**		**Total Credits**	**17**

[* GE for Glass Specialization and *CE for ceramics specialization]

Semester III			Semester IV		
C. No.	**Course Name**	**Credit**	**C. No.**	**Course Name**	**Credit**
ENG-CGCRI -GC 507	Transport phenomena in materials processing	4	ENG - CGCRI-GCP 602	Project and Thesis II	16
ENG-CGCRI -GC 508	Term paper	1	ENG - CGCRI-GCP 603	Seminar I & II	2
ENG-CGCRI -GCP 601	Project and Thesis I	16		Comprehensive viva	2
	Total Credits	**21**		**Total Credits**	**20**

Electives

Glass specialization			Ceramics specialization		
C. No.	**Course Name**	**Credit**	**C. No.**	**Course Name**	**Credit**
ENG- CGCRI -GE 601	Advanced glass science & technology.	4	ENG - CGCRI -CE 601	Advanced structural ceramics and refractories	4
ENG-CGCRI GE 602	Fibre optics and devices.	4	ENG - CGCRI -CE 602	Bioceramic prosthesis and implants.	4
ENG-CGCRI -GE 603	Structural and functional coatings.	4	ENG - CGCRI -CE 603	Ceramic based energy and separation Technology.	4
ENG-CGCRI -Ge604	Nanostructured photonic and optical materials.	4	ENG - CGCRI -CE 604	Electronic ceramics.	4

[Total credits: 75 (Course: 39, Dissertation: 36)]

ENG-CGCRI-GC 501: Introduction to Materials Engineering (3-1-0-4)*

Atomic structure and bonding, crystalline solids, space lattice, Bravais lattice, interstitial sites, superlattice, polymorphism and allotropism, microstructures and metallography.
Crystalline defects, thermodynamics of defects, effect of defects on material properties, amorphous / glassy state and metallic glasses.

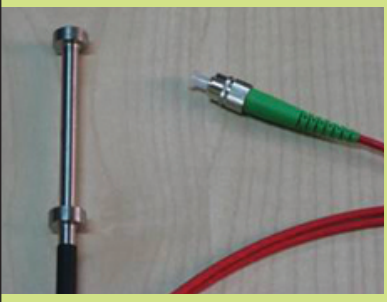
Phase transformation, phase rule, thermodynamic and kinetic principles of nucleation and growth in liquid-solid and solid-state phase transition in pure systems.

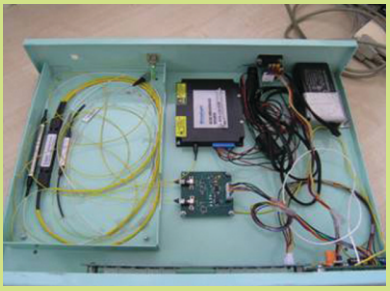
ENG-CGCRI-GC 502 : Materials characterization- I (3-0-2-4)

Common analytical techniques, physical characterization like particle size analysis, surface area and pore size distribution .

X-ray diffraction, small angle X-ray scattering, optical microscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), scanning probe microscopy (SPM).

Thermal characterization of materials (DTA, TGA & DSC)



ENG-CGCRI-GC 503 : Fundamentals of glass & ceramics (3-1-0-4)

Introduction to glass & ceramics, structure of glass and crystals, glass transition, structural and kinetic theory of glass formation.

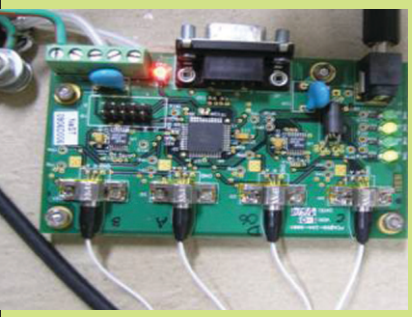
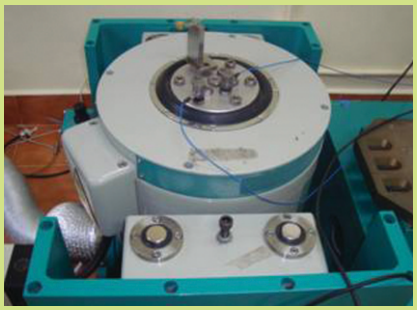
Optical properties of glass & ceramics, filter glass, photochromic and photosensitive glass, laser glass, opal glass, dosimeter glass etc.

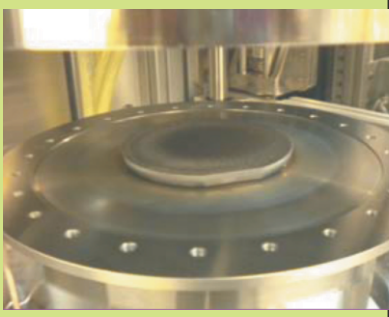
Thermal and mechanical properties of glass and ceramic materials, traditional ceramics, high temperature materials and engineering ceramics, transport properties of glass & ceramics, thermal stress, tempering, creep, friction, fatigue, wear. Chemical durability of glass, surface tension, pH glass electrode, solder glass etc.

Electrical and magnetic properties of glass and ceramics, fast ion conducting glasses, semiconducting glass and ceramics.

Bioglass and bioceramics, nuclear ceramics, 'nano' effects in ceramics and glass.

*[(L-T-P-C) -- Lecture – Tutorial – Practical/Lab – Credit (hour/week)]



ENG-CGCRI-GC 504: Research methodology and applied statistical techniques for materials engineering (3-1-0-4)

Design and implementation of a research project, planning and performing, research modeling, hypothesis, primary and secondary data, analyzing and reporting results.

Professional ethics, ethics in research, IPR, copyright and plagiarism, technical writing and communicating research results.

Methods of classifying data, bar charts, stem and leaf plots, mean, median, mode etc.

Probability, normal and other distributions, uncertainty, accuracy, reproducibility & repeatability

Statistical theories of failure, regression analysis, coefficient of determination, multiple regression, Chi-square distributions .Statistical design of experiment, concept of standard error .

Basics of computer programming, computer-based tools used in management, decision-making

ENG-CGCRI-GC 505: Laboratory safety practice(1-0-0-1)

Safe lab practices, handling, storage, disposal, protective equipment, emergency response, mechanical, electrical, physical, chemical and biological hazards.

2. "Hazardous Laboratory Chemicals Disposal Guide" M. A. Armour

ENG-CGCRI-GC 506: Technical communication (1-0-0-1)

Introduction to writing, editing, and principles of technical and professional communication.

ENG-CGCRI-GC 507 : Transport phenomena in materials processing (3-1-0-4)

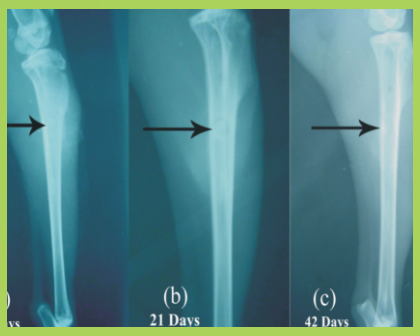
Diffusion in solids, mass transfer in liquids, interphase mass transfer.

Heat transport in solids, liquids and gases, thermal transport phenomena for glass and ceramic processing.

Fluid dynamics of Newtonian and Non-Newtonian flows, rheology, concept of flow regimes, applications of momentum transport to material processing with special emphasis on glass and ceramics.

Fundamental concepts of numerical simulation.

ENG-CGCRI-GC 601: Processing of glass and ceramics (3-0-2-4)



Concept of glassy state and viscosity, commercial glasses, glass forming materials, glass melting furnaces, refining processes of glass melt.

Annealing, tempering and toughening of glass, chemical strengthening of glass, defects in glass; industrial glass processes, manufacture of glass fiber, ceramization of glass, machinable and bioactive glass-ceramics, optical and special glasses.

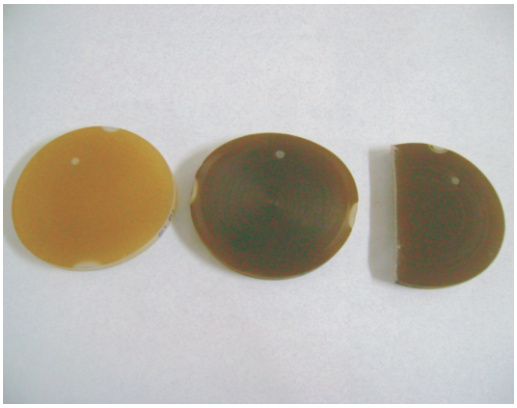
Synthesis of ceramic precursors, packing of ceramic powders, rheological properties of ceramic suspension, ceramic forming processes, forming defects.

Thermal processes in ceramics, polymorphic transformation in ceramics, sintering, hot pressing, cooling of ceramic wares, microwave, laser and plasma assisted processing of ceramics, rapid prototyping, processing machines and furnaces.

ENG-CGCRI-GC 602: Materials characterization- II (3-0-2-4)

Separation Techniques, chromatography, titrimetric analysis, chemometrics, atomic absorption spectroscopy, inductively coupled plasma techniques (ICP-OES and ICP-MS), EPR and NMR spectroscopy, X-ray fluorescence spectroscopy (XRF), auger electron spectroscopy (AES), EPMA, EDS, WDS, electron energy loss spectroscopy (EELS), secondary ion mass spectrometry (SIMS), Rutherford backscattering spectrometry (RBS), X-ray photoelectron spectroscopy, UV-VIS spectrophotometry, FTIR spectroscopy, Raman spectroscopy, ellipsometry .

ENG-CGCRI-GE 601: Advanced glass science and technology (3-0-2-4)



Glass structures and their elucidation by instrumental techniques like nuclear magnetic resonance (NMR), Raman and infrared spectroscopy and transmission and scanning electron microscopy.

Glass preparation by melt-quenching technique, chemical vapour deposition , sol-gel process and other methods.

Fabrication and characterization of optical fibres, optical and ophthalmic glass, photonic glass, laser glass, graded Index glass, photosensitive, photochromic glass etc. Glasses for biomedical and nuclear applications.

Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses.

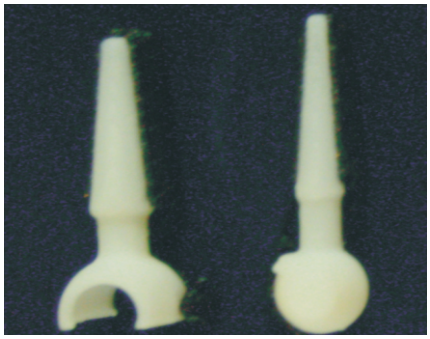
ENG-CGCRI-GE 602: Fiber optics and devices (3-0-2-4)

Types of optical fibers, electromagnetic theory, nonlinear optical properties of fiber, fiber design and fabrication, fiber characterization, optical fiber amplifier, fiber laser and Raman laser, photosensitive fiber and fiber Bragg grating, microstructured fiber, polymer optical fiber, nonlinear fiber optics and mathematical simulations.

Modulation techniques, analogue and digital theory, multiplexing and demultiplexing of signal carrier, TDM and WDM for electronic and optical network, photonic switching, ITU-T recommendations and different telecom protocol.

Optical fiber components and devices, fiber coupler, attenuator, filters, fiber Bragg grating sensor, strain-stress-temperature sensing devices.

ENG-CGCRI-GE 603: Structural and functional coatings (3-0-2-4)



Fabrication of coatings by physical and chemical vapour deposition, wet chemical/sol-gel techniques, thermal and plasma spraying and electroplating, surface modification by ion, electron and laser beams.

Coatings to improve hydrophobic and hydrophilic characteristics, wear resistance, corrosion resistance etc.

Functional coatings and films for electrical, optical, thermal, mechanical, chemical, biochemical and energy saving applications.

ENG-CGCRI-GE 604:Nanostructured Photonic and optical materials (3-0-2-4)

Electromagnetic theory of interaction of light with matter, polarization and diffraction of light, Raleigh scattering, Mie scattering, Brillouin and Raman scattering, optical absorption and emission spectroscopy, optical coherence, stimulated emission, laser, basic properties of highly transparent glasses.

Nano-materials and nanostructure optics, basic concepts of plasmonics , electromagnetics of metals and metal-nano composites, surface plasmon polariton, different coupling schemes, plasmon waveguide and band gap structure.

metamaterials and negative index at optical frequencies, super lensing and imaging.

CSIR-CIMFR

Mine Safety Engineering

Post Graduate Research Programme in Mine Safety Engineering

List of Courses to be offered to Post Graduate Students

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):1-002	MATHEMATICS FOR ENGINEERS	3-0-0-3
2.	ENG(CIMFR):1-311	ROCK MECHANICS AND GROUND CONTROL IN MINING	3-0-1-3
3.	ENG(CIMFR):1-312	ENGINEERING GEOLOGY	3-0-1-3
4.	ENG(CIMFR):1-313	MINE SAFETY LEGISLATIONS AND SAFETY MANAGEMENT	3-0-0-3
5.	ENG(CIMFR):1-314	ROCK MECHANICS INSTRUMENTATION AND MONITORING	3-0-1-3
6.	ENG(CIMFR):1- ----	ELECTIVE - I	3-0-1-3
		TOTAL CREDITS	18

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):2-311	NUMERICAL SIMULATION AND STABILITY EVALUATION OF MINING STRUCTURES	3-0-1-3
2.	ENG(CIMFR):2-312	ADVANCED MINE VENTILATION AND ENVIRONMENT	3-0-1-3
3.	ENG(CIMFR):2-313	ADVANCED MINE SURVEYING AND SUBSIDENCE ENGINEERING	3-0-1-3
4.	ENG(CIMFR):2-314	MINE FIRE, ACCIDENTS AND DISASTERS - ANALYSIS AND PREVENTION	3-0-1-3
5.	ENG(CIMFR):2-315	MINE SAFETY EQUIPMENT: DESIGN, TESTING AND EVALUATION	2-0-1-2
6.	ENG(CIMFR):2- ----	ELECTIVE – II	3-0-1-3
		TOTAL CREDITS	17

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):2-098	M. TECH. DISSERTATION PART-I	0-8-16-16
		TOTAL CREDITS	16

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):2-099	M. TECH. DISSERTATION PART-II WITH VIVA VOCE	0-8-16-16
		TOTAL CREDITS	16

ELECTIVE - I

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):1-315	METHODS OF MINING	3-0-1-3
2.	ENG(CIMFR):1-316	ROCK EXCAVATION ENGINEERING	3-0-1-3
3.	ENG(CIMFR):1-317	RELIABILITY AND MAINTENANCE IN MINING SYSTEMS	3-0-1-3
4.	ENG(CIMFR):1-318	ENVIRONMENTAL MANAGEMENT IN MINING INDUSTRY	3-0-1-3

ELECTIVE - II

SL. NO.	COURSE CODE	COURSE TITLE	L-T-P-C
1.	ENG(CIMFR):2-316	ADVANCED MINING METHODS	3-0-1-3
2.	ENG(CIMFR):2-317	MECHANISATION AND AUTOMATION FOR MINE SAFETY	3-0-1-3
3.	ENG(CIMFR):2-318	ROCK BLASTING AND FRAGMENTATION	3-0-1-3
4.	ENG(CIMFR):2-319	INDUSTRIAL PHYSIOLOGY AND ERGONOMICS	3-0-1-3

L = Lectures	T = Tutorials	P = Sessional/Lab	C= Credits

Note:

1. **Non-Mining students must opt ENG(CIMFR):1-315 as Elective – I. Mining students must opt any other elective subject instead of ENG(CIMFR):1-315.**
2. **On-site training for 4 weeks in mines is mandatory.**

Subject-wise Syllabus for Post Graduate Programme in Mine Safety Engineering

Laboratory Coordinator: Dr. B. Kumar

Programme Coordinators: Dr. P. K. Mandal and D. Kumbhakar

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:3-0-1-3**
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:3-0-1-3**
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:3-0-1-3**
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:3-0-1-3**
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:3-0-1-3**
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:3-0-1-3**
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):1-318	**ENVIRONMENTAL MANAGEMENT IN MINING INDUSTRY**	**L-T-P-C:3-0-1-3**
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:3-0-1-3
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:3-0-1-3**
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:3-0-1-3**
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):2-314	**MINE FIRE, ACCIDENTS AND DISASTERS - ANALYSIS AND PREVENTION**	**L-T-P-C:3-0-1-3**
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:2-0-1-2**
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:3-0-1-3**
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:3-0-1-3**
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 auto-mation; 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:3-0-1-3**
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:3-0-1-3**
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.		

LIST OF FACULTY

SL. NO.	COURSE CODE	COURSE TITLE	FACULTY
1.	ENG(CIMFR):1-002	MATHEMATICS FOR ENGINEERS	Dr. P. Pal Roy, Dr. Ajay K. Singh, Dr. M. Sundararajan
2.	ENG(CIMFR):1-311	ROCK MECHANICS AND GROUND CONTROL IN MINING	Dr. V. K. Singh, Dr. Rajendra Singh, Dr. C. N. Ghosh
3.	ENG(CIMFR):1-312	ENGINEERING GEOLOGY	Dr. A. Sinha, Dr. R. K. Goel, Dr. D. Mahanty
4.	ENG(CIMFR):1-313	MINE SAFETY LEGISLATIONS AND SAFETY MANAGEMENT	A. K. Ghosh, Dr. S. K. Singh, Dr. Ranjan Kumar
5.	ENG(CIMFR):2-314	ROCK MECHANICS INSTRUMENTATION AND MONITORING	Dr. P. K. Mandal, D. Kumbhakar, Dr. P. K. Mishra
6.	ENG(CIMFR):1-315	METHODS OF MINING	Dr. S. K. Mandal, Dr. Arun Kumar Singh, Amar Prakash
7.	ENG(CIMFR):1-316	ROCK EXCAVATION ENGINEERING	Rakesh Kumar, N. Kumar, Dr. C. Swamliana
8.	ENG(CIMFR):1-317	RELIABILITY AND MAINTENANCE IN MINING SYSTEMS	Dr. D. Basak, Dr. S. K. Roy, Dr. Ranjan Kumar
9.	ENG(CIMFR):1-318	ENVIRONMENTAL MANAGEMENT IN MINING INDUSTRY	Dr. (Mrs.) B. Prasad, Dr. Abhay Kr. Singh, Dr. R. Ebhin Masto
10.	ENG(CIMFR):2-311	NUMERICAL SIMULATION AND STABILITY EVALUATION OF MINING STRUCTURES	Dr. G. Banerjee, Dr. A. Kushwaha, Dr. P. K. Mandal
11.	ENG(CIMFR):2-312	ADVANCED MINE VENTILATION AND ENVIRONMENT	Dr. N. Sahay, Dr. J. K. Pandey, Dr. N. K. Verma
12.	ENG(CIMFR):2-313	ADVANCED MINE SURVEYING AND SUBSIDENCE ENGINEERING	Dr. K. B. Singh, Dr. John Lui P., A. Prakash
13.	ENG(CIMFR):2-314	MINE FIRE, ACCIDENTS AND DISASTERS - ANALYSIS AND PREVENTION	Dr. R. V. K. Singh, Dr. I. Ahmed, Dr. D. D. Tripathi
14.	ENG(CIMFR):2-315	MINE SAFETY EQUIPMENT: DESIGN, TESTING AND EVALUATION	Dr. M. K. Singh, Dr. P. K. Mishra, R. K. Vishwakarma,
15.	ENG(CIMFR):2-316	ADVANCED MINING METHODS	A. K. Ghosh, Dr. John Lui P., D. Kumbhakar
16.	ENG(CIMFR):2-317	MINE MECHANISATION, AUTOMATION AND EQUIPMENT OPTIMISATION	Dr. C. N. Ghosh, Dr. G. Banerjee, Dr. P. K. Mishra
17.	ENG(CIMFR):2-318	ROCK BLASTING AND FRAGMENTATION	Dr. P. Pal Roy, Dr. P. K. Singh, Dr. A. K. Raina
18.	ENG(CIMFR):2-319	INDUSTRIAL PHYSIOLOGY AND ERGONOMICS	A. K. Ghosh, Dr. Ranjan Kumar

AcSIR

CSIR-CMERI

Applied & Computational Mechanics

Description of the Programme

1. Faculty Engineering

2. Programme Name Applied & Computational Mechanics

3. Core Courses & Electives

Semester I

Sl.	Course Code	Course Name	Hours/Week			
			L	T	P	C
1	ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	3	0	0	3
2	ENG(CMERI) 1-389	ADVANCED MECHANICS OF SOLIDS	3	0	0	3
3	ENG(CMERI) 1-390	ADVANCED MECHANICS OF FLUIDS	3	0	0	3
4	ENG(CMERI) 1-391	MECHANICAL VIBRATIONS	3	0	0	3
5	ENG(CMERI) 1-392	COMPUTER LAB-I	1	1	2	3
		Total Credits				15

Semester II

Sl.	Course Code	Course Name	Hours/Week			
			L	T	P	C
1	ENG(CMERI) 1-393	FINITE ELEMENT METHODS	3	0	0	3
2	ENG(CMERI) 1-394	ANALYSIS AND SYNTHESIS OF MECHANISMS	3	0	0	3
3	ENG(CMERI) 1-395	COMPUTATIONAL FLUID FLOW & HEAT TRANSFER	3	0	0	3
4	ENG(CMERI) 1-396	COMPUTER LAB - II	0	0	4	2
5	ENG(CMERI) 2-----	Elective I*	3	0	0	3
6	ENG(CMERI) 2-----	Elective II*	3	0	0	3
		Total Credits				17

***For Electives I & II any two subjects can be chosen from the following list**

ENG(CMERI) 2-390	ANALYTICAL MECHANICS	ENG(CMERI) 2-391	FINITE ELEMENT METHODS FOR FLUID DYNAMICS
ENG(CMERI) 2-392	NONLINEAR DYNAMICS & CHAOS	ENG(CMERI) 2-393	MECHANICS OF COMPOSITE MATERIALS

N.B.

In addition to the dedicated courses listed above for this programme, the candidate may also select any other course as elective on the recommendation of his/her thesis supervisor from the courses enlisted in other Post Graduate program & PhD program in the laboratory.

Semester III

Sl.	Course Code	Course Name	Hours/Week			
			L	T	P	C
1	ENG(CMERI) 2-098	MTech DISSERTATION PART-I	0	8	16	16
		Total Credits				**16**

Semester IV

			L	T	P	C
1	ENG(CMERI) 2-099	MTech DISSERTATION PART-II WITH VIVA VOCE	0	8	16	16
		Total Credits				**16**

L = Lectures	T = Tutorial	P = Sessional / Lab	C = Credits

COURSE DETAIL

ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	L-T-P-C : 3-0-0-3
Course Coordinator: Dr. Pradipta Basu-Mandal		
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 & 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(CMERI) 1-389	**ADVANCED MECHANICS OF SOLIDS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Dr. Somenath Mukherjee & Dr. Pradipta Basu-Mandal		
Stress; Stress tensor, stress transformation, principal stresses. Equilibrium. Strain; Linear strain components, Compatibility. Constitutive Relations; Isotropic and orthotropic materials, Failure Theories. Two dimensional elasticity; Mohr's Circle. Polar co-ordinates. Airy's Stress Function for simple systems. Stress concentration factors. Stresses in pressure vessels and rotating discs. Torsion of bars of various sections. Beam bending; Deflections. Three Moment equation. Unsymmetric bending, bending stress and shear and shear center. Variational principles; Equilibrium- Virtual work and the Principle of Stationary Potential Energy, Compatibility- Principle of Stationary Complementary Energy, Castigliano's Theorems, Applications. Elastic Stability; Euler's Bucking Load for columns. Energy methods, Stability of simple frames.		
ENG(CMERI) 1-390	**ADVANCED MECHANICS OF FLUIDS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Dr. Satya Prakash Singh, Dr. Sudipta De & Dr. Dipankar Chatterjee		
Equations of fluid mechanics, Derivation of Navier-Stokes equations, Exact solutions of Navier-Stokes equations, Boundary layers, Exact solution of Boundary layer equations, Approximate methods for solving boundary layer equations, Boundary layer control, Axi-symmetric and three-dimensional boundary layers, Unsteady boundary layers, Stability Analysis, Transitional flows, Concepts of Turbulence, Introduction of Compressible Flows.		
ENG(CMERI) 1-391	**MECHANICAL VIBRATIONS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Dr. Pranab Samanta & Dr. Swarup Kumar Laha		
Free vibrations and response of single-degree-of-freedom systems to harmonic, periodic and general excitations, Energy dissipation and damping, Duhamel's Convolution Integral for response to general time varying excitation. Multi-Degree-of-Freedom Systems; Lagrange's Equations. Free Vibration- The Eigenvalue Problem, Orthogonality of Modal Vectors, Dynamic response by Modal Analysis. Rayleigh's Quotient. Distributed Systems; Exact solutions of free and forced vibrations of bars and beams (axial, torsional and bending). Modal shapes and natural frequencies of continuous systems, Systems with lumped masses, Rayleigh's Principle Approximate Methods; Transfer Matrix Methods, Holzer's Method for Torsional Vibration, Myklestad's Method for bending vibration, Dunkerley's Method, Modal Superposition Methods.		

ENG(CMERI) 1-392	COMPUTER LAB-I	L-T-P-C : 1-1-2-3
Course Coordinators: Dr. Surendra Kumar & Dr. Swarup Kumar Laha		
The Solution of Nonlinear Equations: Iterative Methods, Fixed-Point Iteration, Newton-Raphson and Secant Methods, Polynomial Equations Having Real Roots. Matrices and System of Linear Equations: The Solution of Linear Systems by Elimination, Pivoting, Triangular Factorization, Eigenvalue Problem. Approximation: Uniform Approximation by Polynomials, Data Fitting, Orthogonal Polynomials, Least-Squares Approximation by Polynomials. Differentiation and Integration: Numerical Differentiation, Numerical Integration and Associated Basic Rules, Gaussian Rules. The Solution of Differential Equations: Simple Difference Equations, Numerical Integration by Taylor Series, Runge-Kutta Methods, Multistep Formulae, Predictor-Corrector Methods. Computer programming and code development of the algorithms taught in class.		
ENG(CMERI) 1-393	**FINITE ELEMENT METHODS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Dr. Somenath Mukherjee & Dr. Pradipta Basu-Mandal		
Matrix methods review; Stationary Principles, Rayleigh-Ritz and Hellinger-Reissner Methods. Virtual Work, Governing Equations, Weighted Residual (Galerkin) Method and Weak Forms. Formulations of one-dimensional elements (axial bar, the Euler beam) using Direct and Variational Methods. Solutions to simple truss and frame problems. Interpolation, C0 and C1 elements. Convergence requirements. Isoparametric one and two-dimensional elements; Linear and Quadratic Timoshenko beam elements; shear locking. Linear 2D plane stress /plane strain element; parasitic shear. Reduced integration. Elementary theory of plates and plate elements; Mindlin and Kirchhoff element formulations, Concepts of locking. Full, reduced and selective integration techniques. Axisymmetric elements. The Best-fit paradigm of FEA.		
ENG(CMERI) 1-394	**ANALYSIS AND SYNTHESIS OF MECHANISMS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: P S Banerjee & S N Shome		
Particle and Rigid Body Dynamics – Kinematics and Kinetics. Rigid body rotation, Velocity and Acceleration analysis using Instantaneous Centre (IC) of velocity, Corioli's component of acceleration, Plane motion of a rigid body. Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Four Link Planar Mechanisms and their Inversions Kutzbach and Grubler's criterion, Grashof's criterion, Analysis of plane mechanisms – Graphical and Analytical methods Dimensional synthesis of mechanism; Motion, Path and Function generation, precision point approach, Chebyshev spacing, three position synthesis, graphical and analytical approaches for four link mechanisms. Development of simple algorithms and computer programs for solving typical problems on analysis and synthesis of mechanisms.		
ENG(CMERI) 1-395	**COMPUTATIONAL FLUID FLOW & HEAT TRANSFER**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Prof. Gautam Biswas, Bittagopal Mondal & Dipankar Chatterjee		
Discretisation procedure in Finite-difference and Finite-volume methods, Fundamentals of Fluid Flow Modelling, Staggered and Collocated grids, Explicit methods: MAC, SMAC methods for solving Navier Stokes and Energy equations. Implicit Methods: SIMPLE and SIMPLER. Pressure Solvers: conjugate gradient method, strongly Implicit procedure. Grid-Generation: Algebraic, Transfinite, Poisson equation methods. Finite-volume based Navier-Stokes solution on arbitrary geometry using non-orthogonal grids. Introduction to Turbulence modelling (two equation models).		
ENG(CMERI) 1-396	**COMPUTER LAB - II**	**L-T-P-C : 0-0-4-2**
Course Coordinators: Dr. Surendra Kumar, Avik Chatterjee and Dr. Satya Prakash Singh		
Problem solving utilising application software like ANSYS, ADAMS, FLUENT etc.		

ENG(CMERI) 2-390	ANALYTICAL MECHANICS	L-T-P-C : 3-0-0-3
Course Coordinators: Dr. Somenath Mukherjee		
Optimum Path: Fermat's Principle, Brachistochrone Problem. Calculus of Variation in Mechanics for Conservative Systems. Degrees of Freedom and the Configuration Space. The Concept of Functionals and their Variations. Virtual work, the varied path. Hamilton's Principle of Stationary Action, Lagrange's Equations of Motion. Applications of Lagrange's Equations: Equations of motion of multi-degree of freedom systems. Vibrations of discrete systems (of lumped masses) and continuous elastic systems. Lagrange Multipliers for Constrained Systems. Applications. Hamiltonian Mechanics: The Legendre Transformations, Hamilton's Cannonical Equations of Motion, Applications. Accelerating /rotating reference frames. Dynamics of rotation of rigid bodies. Central force systems; Motion of satellites.		
ENG(CMERI) 2-391	FINITE ELEMENT METHODS FOR FLUID DYNAMICS	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. Satya Prakash Singh & Dr. Gautam Biswas		
Fundamental concepts; strong form, weak form, Galerkin approximation; matrix equations, element and global point of view; numerical integration – Gaussian quadrature; temporal discretization - generalized trapezoidal rule; compressible and incompressible flows; implementation of the methods; issues related to high performance computing.		
ENG(CMERI) 2-392	NONLINEAR DYNAMICS & CHAOS	L-T-P-C : 3-0-0-3
Course Coordinators: Dr. Pradipta Basu-Mandal		
One-Dimensional Flows; Flows on the line & circle: Fixed Points and Stability, Linear Stability Analysis: Uniform-Nonuniform Oscillator, Overdamped Pendulum. Two-Dimensional Flows; Linear Systems with classifications, Phase plane; Phase Portraits, Fixed points and Linearization, Conservative Systems, Reversible Systems. Limit Cycles, Poincare-Bendixson Theorem, Relaxation Oscillations, Weakly Nonlinear Oscillations. Bifurcations; Saddlenode, Transcritical, Pitchfork and Hopf Bifurcations. One-Dimensional Maps; Stability of Fixed Points, Periodic Points, Poincare Map, Logistic Map, Dependence on Initial Conditions. Two-Dimensional Maps; Sinks, Sources and Saddles, Linear Maps, Coordinate Changes, Nonlinear Maps and the Jacobian Matrix, Stable and Unstable Manifolds. Chaos in Two-Dimensional Maps; Lyapunov Exponents: Numerical Calculation. Chaos in Differential Equations; Lorenz Attractor, Lyapunov Exponents for Flows.		
ENG(CMERI) 2-393	MECHANICS OF COMPOSITE MATERIALS	L-T-P-C : 3-0-0-3
Course Coordinators: Dr. Surendra Kumar		
Introduction to Composite Materials, Classification of composites; Fibres and matrices; Manufacturing, mechanical properties and applications of composites. Stress-strain relationships for a unidirectional/bidirectional lamina; strengths, thermal and moisture expansion coefficients. Determination of physical and engineering properties of a unidirectional lamina from the individual properties of the fiber and the matrix, fiber volume fraction, and fiber packing. Determination of the elastic stiffnesses and mechanical loads on laminate based on the values of individual laminae and the stacking sequence. Failure Criteria for a unidirectional composite lamina and a laminate; Design of laminated composite and other issues.		
ENG(CMERI) 2-098	MTech DISSERTATION PART-I	L-T-P-C : 0-8-16-16
ENG(CMERI) 2-099	MTech DISSERTATION PART-II WITH VIVA VOCE	L-T-P-C : 0-8-16-16

CSIR-CMERI

Mechatronics

Detail Description of Programme

SEMESTER I

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	3	0	0	3
2.	ENG(CMERI) 1-381	INTRODUCTION TO MECHATRONICS SYSTEMS	3	0	0	3
3.	ENG(CMERI) 1-382	ADVANCED CONTROL SYSTEM	3	0	0	3
4.	ENG(CMERI) 1-383	CAD AND COMPUTER GRAPHICS	3	0	1	3
5.	ENG(CMERI) 1-384	ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES	3	0	0	3
6.	ENG(CMERI) 1-385	MACHINES & MECHANISMS	3	0	0	3
		TOTAL CREDITS				18

SEMESTER II

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 1-386	ROBOTICS	3	0	1	3
2.	ENG(CMERI) 1-387	MICRO CONTROLLERS & EMBEDDED SYSTEM DESIGN	3	0	1	3
3.	ENG(CMERI) 1-388	DIGITAL SIGNAL PROCESSING & APPLICATIONS	3	0	1	3
4.	ENG(CMERI) 2-----	Elective I	3	0	1	3
5.	ENG(CMERI) 2-----	Elective II	3	0	1	3
		TOTAL CREDITS				15

SEMESTER III

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 2-098	MTech DISSERTATION PART-I	0	8	16	16
		TOTAL CREDITS				16

SEMESTER IV

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 2-099	MTech DISSERTATION PART-II WITH VIVA VOCE	0	8	16	16
		TOTAL CREDITS				16

L = Lectures	T = Tutorial	P = Sessional / Lab	C = Credits

ELECTIVES I & II: TWO SUBJECTS TO BE CHOSEN FROM THE FOLLOWING

COURSE CODE	COURSE TITLE	HOURS/WEEK			C
		L	T	P	
ENG(CMERI) 2-381	INTRODUCTION TO COMPUTER VISION	3	0	1	3
ENG(CMERI) 2-382	ROBOTICS & MACHINE INTELLIGENCE	3	0	1	3
ENG(CMERI) 2-383	INTRODUCTION TO NAVIGATION & DATA FUSION	3	0	1	3
ENG(CMERI) 2-384	MICROSYSTEMS TECHNOLOGY	3	0	1	3
ENG(CMERI) 2-385	ADVANCED MATERIALS	3	0	1	3
ENG(CMERI) 2-386	OPTIMAL CONTROL	3	0	1	3
ENG(CMERI) 2-387	PRECISION MACHINE DESIGN	3	0	1	3
ENG(CMERI) 2-388	NUMERICAL METHODS & COMPUTER PROGRAMMING	3	0	1	3
ENG(CMERI) 2-389	ELECTRO-MECHANICAL SYSTEMS DESIGN	3	0	1	3

N.B.

In addition to the dedicated courses listed above for this programme, the candidate may also select any other course as elective on the recommendation of his/her thesis supervisor from the courses enlisted in other Post Graduate program & PhD program in the laboratory.

COURSE DETAILS

ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	L-T-P-C : 3-0-0-3
Course Coordinator: Dr. Pradipta Basu-Mandal		
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 & 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(CMERI) 1-381	**INTRODUCTION TO MECHATRONICS SYSTEM**	**L-T-P-C : 3-0-0-3**
Course Coordinators: Dr. Ranjit Ray & S.N. Shome		
Overview: What is Mechatronics? Instrumentation and Control System. Sensors & Transducers: Physical Principles & Basic mechanisms in sensor systems, performance characteristics, Different type of Sensors and transducers based on principles – Position and Speed Measurement, Stress and Strain Measurement, Temperature Measurement, Vibration and Acceleration Measurement; Actuators: Electromagnetic Principles, Motors – Electric, Hydraulics & Pneumatics; Mathematical Modeling: State space representation, Model Linearization, Sate model from linear graphs, Bond graphs, Modeling Electromechanical Systems. Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power, Using MATLAB SIMULINK for modeling and simulation Mechatronics systems; Interfacing & Virtual Instrumentation..		
ENG(CMERI) 1-382	**ADVANCED CONTROL SYSTEM**	**L-T-P-C : 3-0-0-3**
Course Coordinators: S. Nandy		
Overview: What is Mechatronics? Instrumentation and Control System. Sensors & Transducers: Physical Principles & Basic mechanisms in sensor systems, performance characteristics, Different type of Sensors and transducers based on principles – Position and Speed Measurement, Stress and Strain Measurement, Temperature Measurement, Vibration and Acceleration Measurement; Actuators: Electromagnetic Principles, Motors – Electric, Hydraulics & Pneumatics; Mathematical Modeling: State space representation, Model Linearization, Sate model from linear graphs, Bond graphs, Modeling Electromechanical Systems. Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power, Using MATLAB SIMULINK for modeling and simulation Mechatronics systems; Interfacing & Virtual Instrumentation.		
ENG(CMERI) 1-383	**CAD & COMPUTER GRAPHICS**	**L-T-P-C : 3-0-1-3**
Course Coordinator: Avik Chatterjee		
Genesis of CAD, Simulation and Visualization, Concepts of CAE and Virtual Prototyping; Geometric Object Modeling – Analytical Representation of Curves & Surfaces, Various Curves and Surfaces (B-Spline, Bezier, NURBS), Intersection calculations, Assembly Modeling Techniques; Computer Graphics: Linear algebra, Screen coordinates, Window coordinates, Graphics library, Rendering pipeline architecture, Homogeneous coordinates & Transformation Matrices, Quaternion, Projection matrices, Types of buffers, Display Interpolation techniques, Lightning, Wireframe, Shading models, Texture mapping, Ray casting, Ray tracing, Normal vectors, Evaluators & NURBS, Modeling of sculpture surface, selection and feedback, Concepts of scenes and scene		

graphics, Hierarchical Modeling Concepts, Kinematic Simulation of an Hierarchical model, Stereo Visualization.		
ENG(CMERI) 1-384	**ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Ms. Uma Datta & J. Roy Choudhury		
Electric Circuits and Components Network Theorems: Thevenin, Norton, Superposition, Maximum Power Transfer. Circuit Analysis, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety. Semiconductor Electronics: Diodes and its' application; Operation, characteristics : Three terminal devices –- BJT, JFET, MOSFET; Four terminal devices- SCR, Diac, Triac; Amplifiers using BJT, FET; Operational amplifiers Modern devices: CMOS, MESFET, MODFET, HBT. Computing: Number, system and code conversion, Logic gates, Boolean algebra, Combinational / Sequential Logic circuits – Latch, RS-, JK-, T-, D-, Flip flops, Buffer Register, Counters, Shift registers. Decoder, Encoder, MUX, DMUX, RAM, ROM, PROM, EPROM, EEPROM, Programmable logic devices.		
ENG(CMERI) 1-385	**MACHINES & MECHANISMS**	**L-T-P-C : 3-0-0-3**
Course Coordinators: P.S. Banerjee & Dr. R. Sen		
Rotation and Plane motion of a rigid body. Kinematic Pairs, Chains, Diagrams. Four Link Planar Mechanisms and their Inversions. Grubler's criterion and Grashof's criterion. Analysis of planar mechanisms – Graphical and Analytical methods Synthesis of planar mechanisms – Motion, Path and Function generation problems - Graphical and Analytical approaches Introduction to Machine Elements – Cams, Gears, Brakes, Clutches etc Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle. Determination of basic dimensions, Synthesis of cam profiles – Graphical and Analytical methods. Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, Simple, Compound and Epicyclic gear trains.		
ENG(CMERI) 1-386	**ROBOTICS**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Dr. Soumen Sen & S.N. Shome		
Robotics introduction; Classification and Components; Rigid body transformation in R3; Homogeneous representation; Denavit-Hertenberg representation; Forward and Inverse kinematics; Redundant and Non-redundant robots; Differential kinematics, velocities, and their transformations; Geometric and analytical Jacobians; Manipulability, Isotropy and Workspace analysis; Manipulator statics; Velocity-force duality; Recursive computation of velocities and accelerations; Manipulator dynamics - Newton-Euler and Euler-Lagrange; Equation of motion; Path planning in joint and task space; Obstacle avoidance and optimal planning; Review of robot control methods; Optimization in robotics; Human-robot interaction; joint and link flexibilities; Walking machines and Exoskeletons; Robot hand and multifingered grasp, manipulation and control; Tendon driven manipulator.		
ENG(CMERI) 1-387	**MICROCONTROLLERS & EMBEDDED SYSTEM DESIGN**	**L-T-P-C : 3-0-1-3**
Course Coordinators: J. Roy Chaudhuri & Shikha		
Introduction to embedded systems and architecture, System design using specification and modeling tools Overview of embedded computing platforms; Microprocessors, Microcontrollers, DSP's and SoC's, Hardware – Software design and partitioning		

Design issues, consideration and trade–offs: Performance memory, power, timing, cost, and development time. Memory hierarchy, System Interfaces and Communication with peripheral units, timers counters, Introduction to Real-time system and Real-time Scheduling Real – time software development: High level languages and Programming issues, Systems performance: Networked embedded systems Future Trends, Applications, Tutorial & Laboratory .		
ENG(CMERI) 1-388	**DIGITAL SIGNAL PROCESSING & APPLICATIONS**	**L-T-P-C : 3-0-1-3**
Course Coordinators: J. Roy Choudhury & SRK Vadali		
Elements of Analog and Digital Signal Processing, Advantages of Digital over Analog, Sampling Theorem. Discrete Time Signals & Systems – Classification, Analysis of LT Systems, of LTI system Response to Arbitrary Inputs, Causality & Stability; Correlation, Convolution, Finite & Infinite Impulse Response, Recursive & Non-Recursive Systems, Difference Equations. Z-Transform – Definition, Properties; Inverse-Z and Analysis in Z-domain. Fourier Analysis – Continuous & Discrete-Time Fourier Series, Power Density Spectrum, Fourier Transform, Frequency-Domain Characteristics of LTI Systems, DFT & Properties, Linear Filtering Using DFT, Frequency Analysis Using DFT, Understanding FFT. Digital Filter Design – Characteristics & Design of Filters. Future Trends, Applications, Tutorial & Hands-on		

ENG(CMERI) 2-381	**INTRODUCTION TO COMPUTER VISION**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Dr. S. Majumdar		
Fundamentals of Computer Vision: Role of vision to achieve simple goals i.e. high level capabilities of vision using cognitive processes, geometric models and low level capability for object perception, representation of images. Computer Vision Research and Application on image formation, camera model and camera calibration, properties of projection, interaction of light and its modeling, perspective modeling, homogeneous coordinate, lens equation, types of image digitizers and image digitizing components. Feature Extraction, filtering and edge detection, fourier transform, texture primitives and texture as a pattern recognition problem, wavelets and multiresolution processing including image pyramids, subband coding, Harr Transform; multiresolution expansions and colour processing. Tutorial on Matlab platform & Project		
ENG(CMERI) 2-382	**ROBOTICS AND MACHINE INTELLIGENCE**	**L-T-P-C : 3-0-1-3**
Course Coordinators: J. Roy Choudhury		
Artificial Intelligence, Computational Intelligence, Various Machine Learning Algorithms ,Pattern Reorganization, Computer Vision, Fuzzy Expert System, Fuzzy Automata. Fundamentals Of Robotics & Automation., Intelligent Robots, Control Systems and Components . Robot Motion Analysis and Control,Robot End Effectors,tactile and vision sensors in robotics Cognitive system for Human machine interaction. Future Trends, Applications, Tutorial & Laboratory.		
ENG(CMERI) 2-383	**INTRODUCTION TO NAVIGATION & DATA FUSION**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Dr. S. Majumdar		
Sensors, Sensing, Model of Sensors & Process uncertainties Introduction to estimation, estimation methods & relation between different estimators State space modeling, LTI Systems & Kalman Filter & Extended Kalman Filter Other Navigation Filters including Bayesian Filters, Information Filters, Particle Filter etc.		

Various Sensors used in Robotics: Accelerometer, Gyro, Compass, Encoder, Laser, Ultrasonic Sensor, Camera, Sonar, InfraRed Sensor, Tactile Sensor etc.
Multisensor Data Fusion Fundamentals; INS, GPS Aided Navigation & Data Fusion
Future Trends, Applications, Tutorial & Laboratory

ENG(CMERI) 2-384	MICRO SYSTEMS TECHNOLOGIES	L-T-P-C : 3-0-1-3

Course Coordinators: Dr. Nagahanumaiah

Introduction: precision engineering; multi-scale product manufacturing paradigms. Micro- Nano Manufacturing: MEMS foundry processes; micro-mechanical processes; regenerative techniques. Process Modelling: material removal mechanisms; FEA and molecular dynamics based simulations. Design of Micro Machines: sources of error; error mapping; precision drives and controls. Sensors for Precision Manufacturing: sensor systems for process monitoring, multi sensor approaches, signal processing and machine vision systems. Precision Metrology: definitions; laser interferometer; AFM; SEM; TEM. Micro Factory Concepts: micro assembly, composite molding, micro robotics, geometric analysis, decision systems, process planning and micro factory layout designs. Micro-nano systems engineering: module applications; micro-nano scale product design; case studies for biomedical, sensors, and nano technology applications. Tutorial and Laboratory practices.

ENG(CMERI) 2-385	ADVANCED MATERIALS	L-T-P-C : 3-0-1-3

Course Coordinators: A. Chaudhuri

Basics: Mechanics of materials, mechanical properties, dislocation theory, mechanical testing methods, creep and relaxation behaviour of common engineering materials
Advanced materials: Polymers, conductive polymers, ceramics, composites, nano-composites, smart materials, high temperature materials, bearing materials, materials for sensors and actuators
Material characterization: Optical and X-ray spectroscopy, diffraction methods (X-ray diffraction, Crystallographic texture measurements, electron microscopy (SEM, TEM, EBSD, etc.), Atomic probe micro analysis (AFM), Thermo gravity analysis
Future Trends, Applications, Tutorial & Laboratory

ENG(CMERI) 2-386	OPTIMAL CONTROL	L-T-P-C : 3-0-1-3

Course Coordinators: S. Nandy

Introduction: Problem formulation, Mathematical model, Physical constraints, Form of optimal control, Performance measures, Static optimization techniques.
Dynamic Programming and related topics: Introduction, Principle of optimality, Hamilton-Jacobi-Bellman equation, Continuous linear regulator problems, Pontryagin's maximum principle, Control with constraints, Time optimal control, Optimal tracking control problem.
Variational Approaches: Calculus of variations, Fundamental concepts, Functionals, Euler's equation, Lagrangian, Variational approach, Optimal control law, Necessary conditions, Linear regulator & tracking problems, Multi-variable optimization problem, Linear Quadratic Regulator.
Optimization Methods: Minimum time problems, Minimum control-effort problems, Kalman Filter, Non-linear system optimization, Gradient optimization techniques, Steepest ascent and decent method, Rosenbrock's conjugate gradient method, David-Fletcher-Power method.

ENG(CMERI) 2-387	PRECISION MACHINE DESIGN	L-T-P-C : 3-0-1-3

Course Coordinators: Dr. N.C. Murmu

Economics, project management and design philosophy, principles of accuracy, repeatability and resolution; error budgeting.
Flexure design - linear and non-linear deflection, stiffness and strength, displacement vs force loads, material considerations, fatigue failure and its prevention.
Bearings: rolling contact bearings, flexural bearings, gas bearings and magnetic bearings and design engineering

surfaces.
System design - manufacturing considerations, materials, structural design, joint design, support system and kinematic coupling design, sensors, actuators and transmissions and system integration driven by functional requirements and operating physics.
Mini Project – application of theory and heuristics to the design of precision mechanical systems.
Tutorial & Mini Project.

ENG(CMERI) 2-388	**NUMERICAL METHODS & COMPUTER PROGRAMMING**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Dr. Partha Bhattacharya		
Introduction, finite floating point arithmetic, catastrophic cancellation, chopping and rounding errors; Solution of nonlinear equations; bisection, , Newton's & Muller's method, fixed point iteration; Numerical optimization, Golden section search, Newton's method optimization; linear algebraic equations; forward Gaussian elimination, pivoting, scaling, back substitution, LU-decomposition, norms and errors, condition numbers, iterations, Newton's method for systems, computer implementation; Interpolation- Lagrange, Newton & inverse ; Numerical Integration; finite differences, Newton cotes, trapezoidal, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ODE; Euler's method, Runge-Kutta method, multi-step methods, predictor-corrector methods, rates of convergence, global errors, algebraic and shooting methods, boundary value problems, computer implementation.		
ENG(CMERI) 2-389	**ELECTRO-MECHANICAL SYSTEMS DESIGN**	**L-T-P-C : 3-0-1-3**
Course Coordinators: Dr. Nagahanumaiah		
Introduction: Electro-Mechanical systems and applications: design and analysis of micro-nano positioning systems; ultra precision screw drives; Dual drive positioning systems; flexural joints; design and kinematics analysis of parallel kinematics platforms. High Speed Power Sstems: Distributed loads in electro-mechanical motion drives; Design and dynamic analysis of high speed spindle. Analysis and Synthesis of Fluid Mechanical Systems: hydraulic actuators, micro fluidic flow problems, solving micro pump system design. Instrumentation: sensors, actuators, encoders, servo mechanisms, laser interferometery and other position calibration techniques. Future Trends: Tutorial & Laboratory practices.		
ENG(CMERI) 2-098	**MTech DISSERTATION PART-I**	**L-T-P-C : 0-8-16-16**
ENG(CMERI) 2-099	**MTech DISSERTATION PART-II WITH VIVA VOCE**	**L-T-P-C : 0-8-16-16**

CSIR-CRRI

Transportation Engineering

ACADEMY OF SCIENTIFIC & INNOVATIVE RESEARCH (AcSIR)
M.Tech Programme (2012-2013)
M. Tech in Transportation Engineering
CSIR- CRRI, New Delhi-110 025
Course Structure

SEMESTER I			**SEMESTER II**		
C. No.	***Course Name***	**L-T-P-C**	**C. No.**	***Course Name***	**L-T-P-C**
ENG(CRRI) 1- 451	Statistical Methods in Engineering	3-0-0-3	ENG(CRRI) 1-452	Design and Construction of Pavements	3-0-0-3
ENG(CRRI) 1- 453	Traffic Engineering & Road Safety	3-0-0-3	ENG(CRRI) 1-454	Transportation Planning	3-0-0-3
ENG(CRRI) 1- 455	Advanced Highway Engineering Materials	3-0-0-3		**Elective I**	3-0-0-3
ENG(CRRI) 1- 457	Advanced Geotechnical Engineering	3-0-0-3		**Elective II**	3-0-0-3
ENG(CRRI) 1-459	Research Methodology	1-1-0-2		**Elective III**	3-0-0-3
ENG(CRRI) 1-461	Laboratory -I (Traffic, Geotechnical Engineering & Highway Materials)	0-0-4-2	ENG(CRRI) 1-456	Laboratory – II (Pavement & Transportation Laboratory)	0-0-4-2
ENG(CRRI) 1-463	Seminar-I	0-0-2-1	ENG(CRRI) 1- 458	Seminar-II	0-0-2-1
Total Credits		***17***	***Total Credits***		***18***
SEMESTER III			**SEMESTER IV**		
C. No.	***Course Name***	**L-T-P-C**	***C. No.***	***Course Name***	***L-T-P-C***
ENG(CRRI) 2- 451	Pavement Evaluation Techniques and Management System	3-0-0-3	ENG(CRRI) 2-452	Dissertation-II	0-0-34-17
ENG(CRRI) 2-453	Dissertation-I	0-0-24-12		Viva Voce	0-0-0-3
Total Credits		***15***	***Total credits***		***20***
Total Course Credits: 70					

ELECTIVE COURSES

Course No.	Course Name
ELECTIVE I	
ENG(CRRI) 2- 454	Bridge and Tunnel Engineering
ENG(CRRI)1-460	Transport and Environment
ENG(CRRI)2-456	Public Transportation System
ENG(CRRI)2- 458	Health Monitoring of Road Infrastructure
ELECTIVE II	
ENG(CRRI)1- 462	Geospatial Techniques for Infrastructure
ENG(CRRI)1- 464	Economic Evaluation of Highway Projects
ENG(CRRI)1-466	Advanced Concrete Technology
ENG(CRRI)2-460	Transport Logistics and Operations
ELECTIVE III	
ENG(CRRI)2- 462	Environmental Impact Assessment of Infrastructure Projects
ENG(CRRI) 1-468	Soft Computing Techniques in Transportation Engineering
ENG(CRRI)2- 464	Airport Planning & Design
ENG(CRRI)2- 466	Disaster Resistant Road Systems

SEMESTER I

ENG(CRRI) 1-451	Statistical Methods in Engineering	L-T-P-C 3-0-0-3
Syllabus	**Representation and Summarisation of data***:* Introduction to statistical methods - attribute, types sources and collection of data; Frequency distribution; Measures of central tendency; Dispersion; Skewness and kurtosis. **Probability and distribution*:*** Concepts of probability; Conditional probability, Independence of events; Baye's theorem, Random variable, Probability distributions; Binomial poisson, uniform, exponential, normal and lognormal distributions and applications to Infrastructure Engineering Problems. **Sampling technique, Distributions and Test of Significance*:*** Sampling techniques; Sampling distribution; Statistical decisions; Tests of significance. Chi-square tests of goodness of fit and for independence of attributes in contingency tables. **Bi-Variate and Multivariate Analysis*:*** Bivariate Models- Related variables, Scatter diagram. Least square curve fitting, Fitting of linear correlation and regression, product moment correlation coefficient. Multivariate Analysis, Principle Component Analysis, Factor Analysis, MANOVA Calculations. **Time series modelling*:*** Components of Time Series; Stationery and Non-Stationery Processes; Smoothing and Decomposition Methods; Correlation and Line Spectral Diagrams; Auto Correlations and Moving Averages; ARIMA. **Advanced Statistical Methods*:*** Operation Research - Network models, Assignment problems, Shortest path methods, Queuing theory, Simulation techniques; Artificial Neural Networks; Genetic Algorithms and Neuro-Genetic models. **Use of computer software's in statistical analysis***:* Descriptive statistics, correlation, regression, analysis of variance, decision making using statistical software like MS-EXCEL, SPSS and MATLAB.
Faculty	Dr. C. Ravisekhar	

ENG(CRRI)1-453	Traffic Engineering and Road Safety	L-T-P-C 3-0-0-3
Syllabus	**Traffic Engineering -** Definition, concepts, scope and utility; **Traffic Flow Theory –** Fundamentals, Scope, relationship between the variables of traffic flow, relationship between speed and traffic elements; **Design of Streets and Highways Infrastructure -** Design Control Criteria for highway alignment, geometry of highway elements; **Highway Capacity -** Review, definition, factors affecting capacity and level of service, capacity of basic freeway segment and two lane bi directional rural carriageways, capacity of signalized intersection, design and operation, evaluation of weaving section; **Design of Intersection and Inter Changes -** Intersection conflict, type of intersections, design of inter-section design elements, ramp gradient, acceleration and deceleration lanes; **Traffic Signal Control and Regulation -** Introduction, warrant for signal phasing, signal aspect and inter green period. Vehicle actuated signal facilities, effect of traffic and environmental factors, optimization of signal approach, Coordination of traffic signals, Area Traffic Control (ATC) system. Regulation of speed, Parking regulation and enforcement; **Street Infrastructure -** Street lighting, vehicle lighting, Lighting of carriageways, Guard rails, traffic signs, highway landscapes and drainage; **Traffic Management -** Traffic management measures, Transport System Management (TSM) techniques and its application, Impact of TSM techniques; **Road Safety -** Characteristics of Road accidents. Planning & Road Design for Safety. Safety Audits (RSA) including RSA Principles and Issues, RSA Procedures and RSA Checklists.
Faculty	Dr. S. Velumurugan, Dr. Nishi Mittal, Subash Chand, Dr.J.Nataraju	

ENG (CRRI) 1-455	Advanced Highway Engineering Materials	L-T-P-C 3-0-0-3
Syllabus	**Soils and Aggregates :** Production of Quality Aggregates, Requirements of Aggregates for High Speed Road Corridors and Airfield Pavements, Factors affecting Adhesion of Bitumen with different Aggregate, Durability, Beneficiation of Marginal Materials, New Materials for Sub base and Base Courses. **Materials for construction of concrete pavement.** **Paving Bitumen:** Composition, Structure and Rheology, Durability, Physical Constants, Performance Based (SHRP) Specifications, Additives viz. Warm Mix Additives and Anti-stripping Agent. **Value Added Bitumen Products:** Specification of Multigrade Bitumen, Rubber and Polymer Modified Bitumen, Bitumen Emulsion, Modified Bitumen Emulsions, Foam Bitumen, Rejuvenating Agents, Pigmentable Bitumen, Fuels Resistant Bitumen, Cut-back Bitumen, Hard Bitumen, Oxidized Bitumen, Sulphur Extended Bitumen. Stone matrix asphalt, cold mixes, micro surfacing, mastic asphalt, porous asphalt, waste plastics.	
Faculty	Dr. P.K. Jain, Dr. Rakesh Kumar	

ENG(CRRI) 1-457	Advanced Geotechnical Engineering	L-T-P-C 3-0-0-3
Syllabus	**Introduction to basic Geotechnical engineering:** Sub soil investigation using SPT, SCPT, DCPT and Plate load tests, analysis of data, shear strength, consolidation characteristics, and settlement analysis. **Ground improvement Techniques:** Soil improvement, dynamic compaction, Lime stabilization, Cement stabilization, organic and inorganic stabilizers, , Blasting, drains, Lime columns, Soil grouting, soft soils, embankments on soft soils, stage construction Vertical sand drains, Prefabricated vertical drains (PVD), Fiber drains, Instrumentation techniques, peizo-meters, settlement gauges, inclinometers, Field tests on soft soils, Stone columns, wet and dry methods, soil nailing, pull out tests, construction process, design methods, case studies. **Stability of slopes and earth retaining structures:** Earthen embankments, specifications, case histories, Finite and infinite slopes, Method of slices, Bishop's method, Factor of safety, submerged case, sudden draw-down case, steady seepage case, long term and short term stability, gravity walls, cantilever walls. **Geosynthetic materials for highway applications: Geotextiles**, woven, non-woven, Geo ties, Geogrids, Properties, applications, Reinforced earth walls, Mechanism, Reinforcement-soil interaction, Analysis and design checks, Internal and external stability, Tests for soil reinforcement, Field applications, software applications. **Environmental Geo-techniques**: Utilization of Waste materials, Reduction of carbon footprint, Hazardous waste containment, slurry wastes, Liners, Stability of landfills, landfill construction, Design aspects, Barriers.	
Faculty	**Dr. Vasant Havanagi, U.K.Guruvittal, A.K.Sinha**	

ENG (CRRI)1- 459	Research Methodology	L-T-P-C 1-1-0-2
Syllabus	Introduction to Research Methodology - Research terminology and the Scientific methods; Designing and Implementing a research project - Types of Research; Measurements in Research - Primary and Secondary data; Analysis of primary and secondary data (quantitative analysis); Communicating Research results; Case studies. Professional Ethics - Ethics in Research – Plagiarism – Nuremberg code etc. Communication skills – presentation – inter personal communication.	
Faculty	Dr. B. Kanagdurai	

ENG (CRRI) 1-461	Laboratory - I Traffic, Geotechnical Engineering and Highway Materials	L-T-P-C 0-0-4-2
Syllabus	**Traffic Engineering** Driver Diagnostics: Driver's Performance Testing and Assessment for evaluating sensory-motor behaviour of driver's safe behaviour and practices. **Geotechnical Laboratory** **Laboratory Tests -** Consolidation Test, Direct shear tests, Relative density tests, CBR test, Unconfined compression test, Durability tests **Field Tests -** Boring, Standard Penetration Test, Dynamic Cone Penetration Test, Static Cone Penetration Test, Plate Load Test. **Highway Materials** Tests on Aggregate, Bitumen, Modified bitumen, Cement and emulsions	
Faculty	**Dr. Vasant Havanagi, Dr.Neelima Chakraborty, Satish Pandey,**	

SEMESTER II

ENG(CRRI)1-452	Design and Construction of Pavements	L-T-P-C 3-0-0-3
Syllabus	**Introduction**: Types, components and comparison of pavements, Factors affecting design/performance of pavements, Road and airport pavements; **Stresses and deflections in flexible pavements:** Stresses and deflections in homogenous masses; layer theories; wheel load stresses, ESWL computation, Repeated loads and EWL factors; sustained loads. Transient traffic loads. Flexible pavement design methods; **Stresses in rigid pavements:** Types of stresses and causes, general considerations in rigid pavement analysis, EWL; **Rigid pavement design:** Design of CC pavements, Types of joints in cement concrete pavements and their functions, joint spacing ; design of joint details; **Equipment/Machinery in highway construction:** Equipments for excavation, grading and compaction. Equipments for bituminous, cement concrete, stabilised and composite pavements. Earthwork construction, problems, quality control aspects. Design factors; **Flexible pavements:** Specifications of materials, choice, construction method and field control checks for various specifications of sub-base, base, binder and surface course layers and mix design methods; **Cement concrete pavement layers:** Specifications and method of cement concrete pavement construction, quality control aspects; **Drainage:** Design and construction of drainage systems for road pavements, drainage materials, procedures and guidelines. Maintenance of pavements, shoulders and drainage; **Hill Roads:** Special problems in construction and maintenance of hill roads; landslides, causes, investigations and remedial measures.	
Faculty	M.N. Naghabushana, Dr. Vasant Havanagi , Binod kumar	

ENG(CRRI)1-454	Transportation Planning	L-T-P-C 3-0-0-3
Syllabus	**Introduction to Transportation Planning***:* Introduction to transport planning practices, transportation problem and problem domain in Indian context, objectives and constrains, flow chart for transportation planning process. **Transportation Planning Process***:* Zoning & travel demand surveys, transportation planning process-inventory, model building, forecasting and evaluation stages. **Trip Generation Models:** Regression models, Category analysis, House hold models, Trip attractions, Quick Response Techniques. **Trip Distribution Models***:* Trip distributions Models-Growth factor models, Gravity models, Opportunity models. Mode Choice Models: Utility maximisation theory, functional form, elasticity of demand, modelling mode choice - probabilistic models such as probit, logit model etc. Network Assignment Models: Elements of transport networks, shortest paths, All-or-Nothing (AON) Assignment, equilibrium, user equilibrium (UE), stochastic user equilibrium (SUE), and Frank Wolfe (FW) Algorithm and MSA algorithm. **Land Use Transportation Models***:* Location Models-Opportunity models, accessibility models, lower based land use transportation models in practice, Lowry models. **Urban and Regional Mass Transport Planning***:* Introduction to Urban and Regional mass transportation planning, planning for intermediate public transport (IPT) **Planning for non motorised transport:** Issues of non motorised transport, planning for bicycles, pedestrians and other slow moving vehicles.	
Faculty	Dr. Purnima Parida, Dr. S. Gangopadhyay, Dr. E. Madhu	

ENG(CRRI)1- 456	Laboratory - II Pavement Engineering and Transportation Engineering	L-T-P-C 0-0-4-2
Syllabus	**Pavement Evaluation** Benkelman beam deflection, Roughness measurement by Bump integrator, Dipstic, Modulus measurements by Falling Weight Deflect meter, Collection of Road inventory data with Network survey vehicle. Bituminous mix design, Concrete mix design, Compression and flexural strength tests, Non destructive tests for concrete. **Transportation Engineering** Testing and Evaluation of Retro-Reflective control Devices and High Security Registration Plate for registration system for improving night time road safety. Road Safety monitoring with Automatics Vehicle Counters cum Classifiers, Radar Gun and Speed Gun devices. Air pollution measurement, Noise measurement	
Faculty	**Dr. Vasant Havanagi, Dr. Neeraj Sharma, Dr. J. Natraju**	

Elective Courses

Elective I

ENG(CRRI) 2-454	Bridge and Tunnel Engineering	L-T-P-C 3-0-0-3
Syllabus	**Bridge engineering** - Classification and components, Site investigation and planning of bridge and tunnel. Design considerations- geometric, hydrological, scour, soil, loading. Introduction to bridge codes. Analysis of bridges. Design of RC superstructure: Slab, T-girder, box girders. Considerations for Integral bridges. Pre-stress concrete bridges-design considerations, I-girder, box-girder bridges. Design of steel superstructure: truss, plate girder, composite bridge decks. **Introduction to long span bridges** - Cantilever, arch, cable stayed, suspension bridges. Design of substructure and foundation: pier and abutments, wing walls and approaches. Design of open, pile, well foundations. Design of appurtenances: bearing, expansion joints, parapet/ crash barrier etc. Construction methods and quality control. **Tunnel engineering** - Introduction to rock mechanics: engineering classification and strength criteria, rock slope stability. **Tunneling** - Feasibility, environmental impact, construction method, problems associated with tunneling, construction subsidence. Design parameters, loading, ground condition in tunneling, application stereographic projection, rock mass support interaction analysis, stress distribution around opening, design of support system.	
Faculty	Dr. Lakshmy Parameswaran, Dr. R.K. Garg, Dr. Rajeev Goel .	

ENG(CRRI)1- 460	Transportation and Environment	L-T-P-C 3-0-0-3
Syllabus	Sources of air pollution; road transport related air pollution; air pollution meteorology; control of vehicular emissions in urban areas; role of public transportation & non-motorized transport in improving urban air quality; traffic noise and vibration and its mitigating measures; introduction to vehicular air & noise pollution modeling; vehicular emissions loads estimation; measurement & analysis of vehicular emissions; vehicular emission standards and norms; alternate fuels; road transport and GHG emissions, environmental clearance for road & highway projects in India; EIA requirements for highway projects.	
Course-Coordinator	Dr. Anil Singh, Dr.Niraj Sharma	

ENG(CRRI) 2-456	Public Transportation System	L-T-P-C 3-0-0-3
Syllabus	Development of Public Transit System: Historical Growth, Modes of public transport and comparison, public transport travel characteristics, technology of bus, rail, rapid transit systems, basic operating elements. Transit Network Planning: Objectives, principles, Intercity and Regional transit system, considerations, transit lines – types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, network evaluation, accessibility considerations. Transit Scheduling: Components, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling. Transit Infrastructure Facilities: Design of bus stops, design of terminals – principles of good layout, types of layout, depot location, twin depot concept, crew facilities and amenities. Transit Agency and Economics: Organisational structure of transit agency, management and personnel, transit system statistics, performance and economic measures, operations, fare structure.	
Faculty	Dr. Mukthi Advani	

ENG(CRRI)2- 458	Health Monitoring of Road Infrastructure	L-T-P-C 3-0-0-3
Syllabus	**Introduction** : Measurement & Instrumentation Principles & Technologies, Data Acquisition systems, Signal processing, Intelligent & Virtual Instrumentation **Health Monitoring of Bridges:-** Measurement of Parameters, Sensors/Transducers technologies, Measurement & Health monitoring Techniques: Vibration signal analysis, Strain gage based Instrumentation, Destructive & Non destructive testing, Load Test, etc **Health Monitoring of Pavements:** Structural and Functional Evaluation of Pavement: Pavement Surface Defects, Skid Resistance, Pavement Deflection using FWD, Benkelman Beam and condition survey using Modern Instrumental Methods.	
Faculty	D.C .Sharma	

Elective II

ENG(CRRI)1-462	Geospatial Techniques for Infrastructure	L-T-P-C 3-0-0-3
Syllabus	Definition and scope of geospatial technology, Techniques in geospatial technology, Historical development of geospatial technologies. Introduction of geographic information system (GIS) and Remote sensing techniques. Essential components of GIS data acquition, Geo-referencing and Geo-reference systems. GIS data: spatial and non-spatial, raster, metadata, Topology and topological models; Spatial data acquisition; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Data acquisition and conversion techniques, data interpretation, query development, spatial querying, spatial analysis, advanced analysis tools, model design & development, customization issues, case studies in GIS applications in infrastructure projects. Implementing GIS based Management Information; GPS surveys applications to various projects. Digital Elevation Model (DEM). Introduction to various GIS software.	
Faculty	A.Mohan Rao, Dr. Neelam Jain	

ENG(CRRI)1-464	Economic Evaluation of Highway Projects	L-T-P-C 3-0-0-3
Syllabus	**Introduction to Highway Projects:** National planning and project choice; Project definition and formulation; Project appraisal and evaluation; Economic analysis. **Concepts of Economic Analysis:** Cost-benefit, Cost-effectiveness analysis; Financial and economic analysis; Salvage value; Environmental economics. **Project Evaluation:** Stages involved in economic evaluation; Feasibility studies, Techniques of economic evaluation; Project evaluation practices. **Determination of Costs:** Total transportation costs – Construction cost; Road user costs; Road maintenance cost; Evaluation of environment and congestion costs. **Valuation of benefits:** Direct benefits - Savings in user cost, etc.; Indirect benefits -socio-economic benefits, distributional benefits, etc.; Estimation of benefits from construction of turnkey projects, rail/road over bridges, low volume rural roads and urban transportation projects; Economic function of transportation projects; Economic evaluation using the various benefits incidence Tables. **Comparing Costs and Benefits:** Method of comparison – NPV, IRR, B/C ratio and other methods; comparison of project alternatives; Risk and uncertainties; Application of HDM and RED software. **Financial Analysis:** Estimation of financial costs and returns; Financial aspects of BOT, SPV projects; Determination of toll rates, annuity, etc. **Case Studies -** Expressways, two/four lane highways, rural roads, urban roads, bridge projects, bye-pass roads, urban transport projects.	
Faculty	.Dr. K. Ravinder, Dr. B.Kanagadurai, Dr. S. Velumurugan	

ENG(CRRI)1-466	Advanced Concrete Technology	L-T-P-C 3-0-0-3
Syllabus	**Concrete** - Characterisation of ingredients. Concrete mix design. Concrete science (mixing, transportation, placing and curing of concrete). Properties of fresh and hardened concrete. New materials for concrete, **Quality control** - Quality assurance of concrete. Durability of concrete. **Concrete technology**- Sustainable construction.	
Faculty	Dr. Rakesh Kumar, Dr. VVLK Rao	

ENG(CRRI)2-460	Transportation Logistics and operation	L-T-P-C 3-0-0-3
Syllabus	Logistics, movement of good, inventory , procurement, ware housing, transportation planning including urban and interregional goods transport, dedicated freight corridors, integrated transport managements , operation, network, Management, Transport Models, Transport Control and Telemetric, Public Transport, Project and ITP, Transport Appraisal.	
Faculty	Dr. Ravindra Kumar	

Elective III

ENG(**CRRI)2-462**	**Environmental Impact Assessment of infrastructure Projects**	**L-T-P-C 3-0-0-3**
Syllabus	**Introduction and Scope**- EIA, EIA and Sustainable Development, Environmental Impacts of Infrastructure Projects. Introduction of applicability of Various Environmental laws to EIA of Infrastructure Projects. Salient Features of EIA Notification (Sep. 14th , 2006); **Impact assessment** - Assessment of Impact on Air, Water, Soil and Ground Water, Noise, Biological Environment and Socio-economic Environmental including Resettlement and Rehabilitation (R&R) issues. Environmental Assessment Methods and Techniques, Matrices, Network and Checklist Methods. Prediction Technique for Quality of Environment Attributes.**Noise & Vehicular Pollution Modelling:** Evaluation Methods. **Environmental Quality Standards** - Regulations and Legislations; **Control measures** - Management, Air & Noise Pollution Control & Preparation of Environmental Management Plan (EMP) including Resettlement & Rehabilitation (R&R) Aspects. Case Studies- EIA of Road, Buildings, **Metro Rail &** other infrastructure Projects Laboratory Experiments/ Field Studies Related to EIA Studies viz. Air Quality and Noise Pollution Measurements, Water Quality Analysis& Traffic.	
Faculty	Dr.Niraj Sharma, Dr. Anil Singh, Dr. Anuradha Shukla	

ENG(CRRI)1- 468	**Soft Computing Techniques in Transportation Engineering**	**L-T-P-C 3-0-0-3**
Syllabus	**Introduction to Neural Networks**: Artificial Neuron and its models, activation functions, Neural Network architecture, single layer and multilayer feed forward networks, various learning techniques, convergence rules. **Neural Network Models:** Architecture, perception models, Single ANN model, Multi layer ANN model, back propagation learning models, effect of learning rules, back-propagation algorithm, factors effecting back-propagation algorithm, Radial basis function. Bayesian networks, Application of ANN models to traffic engineering and transportation planning. **Introduction to Fuzzy Logic**: Basic concepts of fuzzy logic, fuzzy sets, fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and crisp relations. **Fuzzy logic Models:** Membership functions, interference in fuzzy logic, fuzzy if then rules, fuzzy implications and fuzzy algorithm, fuzzyfications and de-fuzzyfications, fuzzy controllers. Applications of fuzzy logic in Traffic and Transportation Planning. **Genetic Algorithm:** Basic concepts, Procedure of GA, Genetic representations, Initialization, genetic operators, mutation, generation, cycle. Applications related to transportation engineering. **Hybrid Modeling Techniques:** Integration of Neural Networks, Fuzzy Logic and Genetic Algorithms, Genetic Algorithm Based Back propagation Networks, Fuzzy Back Propagation Networks.	
Faculty	Dr. E. Madhu, Dr. Ch. Ravisekhar	

ENG(**CRRI)2-464**	**Airport Planning, Design and Construction**	**L-T-P-C 3-0-0-3**
Syllabus	Airport Planning and Design Aircraft characteristics related to airport design; Airport configuration - runway configurations, relation of terminal area to runways, runway orientation; Geometric design of the airfield - ICAO and FAA design standards, runways, taxiways, holding aprons and aprons; Planning and design of the terminal area - apron-gate system, size and number of gates, aircraft parking configurations, the passenger terminal system; airport lighting and marking; air traffic control; airport planning and air travel demand forecasting; Structural design of airfield pavements.	
Faculty	R.K. Srivatsava, Dr. Devesh Tiwari, M.N. Nagabushana	

ENG(**CRRI)2-466**	**Disaster Resistant Road System**	**L-T-P-C 3-0-0-3**
Syllabus	Introduction to various hazards/disasters, Basic concept and principles, Global & Indian scenario on various disasters, Seismic evaluation of road infrastructures, Concept of wind, cyclone and flood engineering for design of roads and bridges. Mass movement hazard classification, hazard assessment, vulnerability & risk analysis, instrumentation &monitoring, Risk reduction and mitigation strategies and methods. Use of remote sensing and GIS techniques in mass movement studies. Choice of construction methodology and sequence in disaster prone areas, maintenance practices and their implementation.	
Faculty	Dr. Kishore Kumar, P.S.Prasad, Guruvittal, Dr. Lakshmy	

Core Courses

SEMESTER III

CRRI- 2-451 Pavement Evaluation Techniques and Management System	L-T-P-C 3-0-0-3
Syllabus	**Pavement Evaluation** Evaluation of functional performance and serviceability of pavements, evaluation of pavement structural capacity, distress types and causes, safety- skid resistance etc., combined measures of pavement quality, data management. **Introduction to PMS -** Prediction models for pavement deterioration, rehabilitation and maintenance strategies, Framework for pavement design, characterization of physical design inputs, basic structural response models, Intervention criteria for maintenance planning, economic evaluation of alternate pavement design strategies – selection of optimal design strategy, HDM – 4 & other tools, Pavement life cycle assessment. Implementation of PMS, Asset Management.
Faculty	K.Sitaramanjaneylu, Dr. Devesh Tiwari

CSIR-IICT

Process Engineering Science

Integrated M.Tech-PhD Program in Process Engineering Science

Semester-wise details of Course Work

SEMESTER I

Course No.	Title	L-T-P-C	Credits
PES 611	Numerical methods and Process Modeling	3-1-0-3	3
PES 612	Advanced Separation Processes	4-0-0-3	3
PES 613	Reaction Technology	4-0-0-3	3
PES 711	Process Engineering	4-0-0-4	4
PES 614	Advanced Chemical Engineering Thermodynamics	3-0-1-3	3
	Total		**16**

SEMESTER II

Course No.	Title	L-T-P-C	Credits
PES 621	Advanced Process Design	3-1-0-3	3
PES 622	Advanced Process Optimization	3-1-0-3	3
PES 721	Process Integration and Intensification	4-0-0-4	4
PES 623	Membrane Technology	3-0-1-3	3
PES 624	Advanced Process Monitoring and Control	4-0-0-3	3
	Total		**16**

SEMESTER III

Course No.	Title	L-T-P-C	Credits
PES 631	Research Methodology & Technical Communication Skills	4-0-0-3	3
PES 63x	Elective	4-0-0-3	3
PES 635	Project Proposal & Seminar		12
	Total		**18**

Electives in SEMESTER III

Course No.	Title	Credits
PES 632	Artificial Intelligence in Chemical Engineering	3
PES 633	Biochemical Engineering	3

SEMESTER IV

Course No.	Title	Credits
PES 641	Dissertation Seminar Final Presentation & viva voce	6
PES 642	Dissertation Report	14
	Total	**20**

Brief Course Description: Process Engineering Science

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

List of Faculty Members : Process Engineering Science

Core Chemical Engineering Faculty

S. No.	Name	Designation
1	Dr. K Yamuna Rani	Scientist-F
2	Dr. B Satyavathi	Scientist-EI
3	Dr. S Sridhar	Scientist-EI
4	(Dr.) Usha Virendra	Scientist-F
5	(Dr.) T Prathap Kumar	Scientist-EII
6	(Dr.) C Sumana	Scientist-EI
7	Mr. K H V Prasad	Scientist-F
8	Mr. P Anand	Scientist-C

Additional Faculty Members enrolled in Engineering Science from various divisions: **8**

CSIR-IIP

Advanced Automotive Technology

Advanced Automotive Technology

Semester-wise Programme Outline

I SEMESTER			II SEMESTER		
C. No.	***Course Name***	***Credits***	***C. No.***	***Course Name***	***Credits***
ENG(IIP): 3-610	Advanced Thermodynamics	3	ENG(IIP): 3- 614	Automotive Lubricants	3
ENG(IIP): 2-611	Internal Combustion Engines	3	ENG(IIP): 3- 615	Automotive Emissions & Fuel Quality	3
ENG(IIP): 2- 593	Analytical Methods used in Petroleum Industry	4	ENG(IIP): 3- 616	Automotive Test Equipments & Procedure	3
ENG(IIP): 2- 612	Tribology & Tribo-component Design	3	ENG(IIP): 2- 617	Alternative Fuels	3
ENG(IIP): 2- 613	Chemistry of Lubricants	3	ENG(IIP): 2- 594	Renewable Energy	4
Total Credits		16	Total Credits		16
III SEMESTER			**IV SEMESTER**		
C. No.	***Course Name***	***Credits***	***C. No.***	***Course Name***	***Credits***
ENG(IIP): 3- 6xx	Elective Courses	2		Thesis Report	10
ENG(IIP): 1- 623	Research Methodology	1			
ENG(IIP): 3- 624	Seminar on Special Topic (Opted by Student)	2		Thesis Viva Voce	10
ENG(IIP): 3- 625	Thesis Proposal Seminar & Report	12			
Total Credits		17	Total Credits		20

Course Description

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): 3- 6xx
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

Electives:

Faculty	Course No	Title	Credits
Dr. S. K. Singal	ENG(IIP): 3-618	Modelling and Simulation	2
Sh. G. D. Thakre	ENG(IIP): 3-619	Maintenance Engineering	2
Sh. Pankaj Arya	ENG(IIP): 3-620	Industrial and Domestic Combustion	2
Dr. S. K. Singal	ENG(IIP): 3-621	Homogeneous Charged Compression Ignition (HCCI) Engines	2
External Faculty	ENG(IIP): 3-622	Engine and Vehicle Design	2

CSIR-IIP

Advanced Petroleum Science and Technology

Semester-wise Programme Outline

I SEMESTER			II SEMESTER		
C. No.	***Course Name***	***Credits***	***C. No.***	***Course Name***	***Credits***
APST601	Petroleum Refining and Petrochemicals	3	APST703	Catalysis in Petroleum Refining	
APST602	Hydrocarbon Chemistry	3	APST704	Advanced Separation Processes	
APST 701	Advanced Thermodynamics	3	APST705	Advanced Conversion Processes	
APST 702	Chemical Reaction Engineering	3	APST 603	Renewable Energy Conversion Technologies	
APST 603	Analytical Methods used in Petroleum Industry	4	APST 610	Seminar on Special Topic (Offered by Mentors)	
Total Credits		***16***	***Total Credits***		***16***
III SEMESTER			**IV SEMESTER**		
C. No.	***Course Name***	***Credits***	***C. No.***	***Course Name***	***Credits***
APST 7xx	Elective Courses	3	APST731	Thesis Report	10
APST 501	Research Methodology	1			
APST 720	Seminar on Special Topic (Opted by Student)	2	APST732	Thesis Viva Voce	10
APST 730	Thesis Proposal Seminar and Report	12			
Total Credits		***18***	***Total credits***		***20***

Course Description

Course No: APST-601
L-T-P-C: 3-0-0-3
Course Title: Introduction to Petroleum Refining and Petrochemicals- 3 Credits
Coordinating Faculty: Dr A K Chatterjee
List of Faculty : Dr A K Chatterjee, Dr R C Saxena, Dr D Tandon (Ex IIP), Dr T Bhaskar, Dr S M Nanoti, Dr H B Goyal (Ex IIP), Dr A K Gupta (Ex IIP)

Petroleum Refining:

- Primary operations: Gas and liquid separations; Treatment of crude oil before transportation; Transportation of crude oil; Pretreatment of Crude; Crude distillation: atmospheric operations ; vacuum operations; Secondary Operations: Catalytic cracking; hydro cracking; Visbreaking; Coking; Reforming; Hydro treating; Solvent treating

Petrochemicals:

- Basic Building blocks; Gases; Liquids; C_1-Chemistry; Petrochemicals from n-paraffins; Olefins production; Petrochemicals from olefins; Petrochemicals from aromatics; Polymer chemistry; Polymer products; Synthetic fibers; Synthetic rubber; Refinery - Petrochemical Integration, Future Prospects

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr A K Chatterjee	Chief Scientist	20
Dr. R C Saxena	Senior Technical Officer (3)	6
Dr. D Tandon	Ex IIP	5
Dr. T Bhaskar	Senior Scientist	4
Dr.S M Nanoti	Chief Scientist	2
Dr. A K Gupta	Ex IIP	4
Dr H B Goyal	Ex IIP	5

Course No: APST 602
L-T-P-C: 3-0-0-3
Course Title: Hydrocarbon Chemistry- 3 credits
Coordinating Faculty: Dr Suman Lata Jain
List of Faculty: Dr Bir Sain, Dr Suman L Jain

General Introduction: Localized Chemical Bonding, Delocalized Chemical Bonding, Bonding Weaker than Covalent, Carbonium ion, Carbanions and Free Radicals, Acid and Bases.

Chemistry of Petroleum Refining Processes: Chemistry of Crude Oil, Chemistry of Thermal Cracking Processes (Chemistry of Thermal Cracking, Visbreaking, Coking and Steam Cracking Processes), Chemistry of Catalytic Cracking Processes (Chemistry of Catalytic Cracking, Fluid Catalytic Cracking , Hydro cracking and Steam Hydrocarbon Reforming Processes), Chemistry of Reforming Process (Chemistry of Thermal Reforming and Catalytic Reforming Processes),, Chemistry of Alkylation process, Chemistry of Isomerization Process, Chemistry of Desulfurization Processes (Chemistry of LPG Sweetening and Related Processes, Chemistry of Hydrodesulphurization Process).

Chemistry of Petrochemical Processes: Introduction to Petrochemicals (Feedstock for Petrochemicals, Integration of Refining with Petrochemicals, Structure of Petrochemical Complex), Chemistry of Alkylation Reactions and their Applications in Petrochemical Industry, Chemistry of Oxidation and Oxygenation Reactions and their Applications in Petrochemical Industry, Chemistry of Carbonylation Reactions and their Applications in Petrochemical Industry, Chemistry of Halogenation, Sulphonation, Nitration reactions and their Applications in Petrochemical Industry, Chemistry of Olefin Metathesis Reaction and its Applications in Petrochemicals, Utilization of CO_2 for Production of Value Added Chemicals, Challenges and Management of CO_2 in Petroleum Refining

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr. Bir Sain	Emeritus Scientist	36
Dr. Suman L Jain	Senior Scientist	4

Course No: APST 701
L-T-P-C: 3-0-0-3
Course Title: Advanced Thermodynamics – 3 Credits
Coordinating Faculty: Dr. Jasvinder Singh
List of Faculty: Dr. Jasvinder Singh, 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 using the generalized correlation's based on the viral equation of state; properties of fluid mixtures using Redlich-Kwong equation of state and Pitzer's correlation's; VLE and flash calculations using the Redilich – Kwong equation of state.

Multicomponent and multiphase systems
Criterion of phase equilibrium; Ideal solutions and use of Roult's Law to generate P-X-Y and t-x-y diagrams for ideal solutions; flash calculations for ideal solutions; non ideal behavior, partial properties; Gibb's – Duhem equation; fugacity and fugacity coefficient for pure components and for species in solution; calculations of fugacity coefficient using generalized correlation; the excess Gibbs energy; Lewis – Randall rule – activity coefficients from vapor-liquid equilibrium (VLE) data. Analysis of Azeotrops; Miscible, partially miscible and immiscible systems;

Solution thermodynamics
Fundamental residual – property relation and fundamental excess – property relation; evaluation of partial properties and property changes of mixing; equilibrium and stability; stability requirement for binary vapor-liquid equilibrium; VLE of systems of limited liquid phase miscibility. The nature of Phase equilibrium; the phase rule, Duhem's theorem; description of phase diagrams; low-pressure VLE from correlation of data – equations of Margules, van Laar, Wilson, UNIQUAC, UNIFAC; dew-point and bubble – point calculations; flash vaporization calculations; ideal solute behaviour based on Henry's law.

Chemical reaction equilibrium
Reaction co-ordinate; equilibrium criteria for chemical reactions; equilibrium constant and the effect of temperature; temperature and pressure effects on

conversion; Duhem's theorem for reacting systems; simple examples of multi-reaction equilibrium.

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.

- **Distribution of Lectures**

Name	Designation	No. of Lectures
Dr. Jasvinder Singh	Senior Technical Officer (3)	36
Dr. M O Garg	Director	4

Course No: APST 702
L-T-P-C: 3-0-0-3
Course Title: Chemical Reaction Engineering - 3 Credits
Coordinating Faculty: Sudip K Ganguly
List of Faculty: Sudip K Ganguly

Course Description

An overview of Chemical Reaction Engineering; Reaction Kinetics; Interpretation of Batch Reactor Data; Introduction to Reactor Design: Batch, CSTR, PFR, and Semi-Batch Reactors; Design of Reactors: Single Reactions, Parallel Reactions and Multiple Reactions; Choice of Right Reactor Type: Heuristics Rules; Langmuir Hinshelwood treatment for obtaining Rate Law: Basics of Mechanistic Kinetics; Case studies of Mechanistic Kinetics; Heterogeneous Systems; Residence Time Distribution Studies: RTD Theory; Axial Dispersion Model and N Tank Series Models. Case studies on reaction kinetics based on petroleum refining operations like Hydrodesulphurization; Isomerisation; Reforming; Concepts of DOE and parameter estimation.

- **Distribution of Lectures**

Name	Designation	No. of Units
Sudip K Ganguly	Principal Scientist	40

Course No: APST 603
L-T-P-C: 2-0-4-4
Course Title: Analytical Techniques in Refineries – 4 Credits
Course Coordinator: Dr Y K Sharma
List of faculty members: Dr S S Ray, Dr R C Chauhan, Shri Pankaj K Kanaujia, Shri A Majhi, Shri 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; X-ray 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 Units
Dr. Y K Sharma	Senior Principal Scientist	10
Dr. S S Ray	Senior Principal Scientist	13
Dr Pankaj K Kanaujia	Scientist	9
Dr R K Chauhan	Senior Technical Officer (3)	5
Shri Sarabhjeet Singh (Practicals)	Senior Technical Officer (3)	3
Dr.A Majhi	Scientist	2

Course No: APST 703
L-T-P-C: 2-1-2-4
Course Title: Catalysis in Petroleum Refining – 4 Credits
Course Coordinator: Dr S Tripathi
List of Faculty: Prof D K Chakraborty (External Faculty); Dr N Viswanadham; Dr R Bal; Shri P Vijayanand; Dr A Sinha; Dr N Atheya; Dr S Tripathi; Dr VVDN Prasad; Dr T V Rao
Total Units: 45

Course Description

Introduction to Catalysis and Basic Definitions, Principles of Adsorption and Desorption, Physical Adsorption – Types of Isotherms, Thermodynamics of Adsorption, Chemisorption, Geometrical, Electronic and Energetic Factors in Catalysis, Chemical Nature of Catalysts, Fundamentals of Catalytic Kinetics and Kinetic Models, Diffusion in Catalysis, Gaseous, Liquid and Surface Diffusion, Catalysis by Metals and Semiconducting Solids, Clean Metal Surface, Fundamentals of Catalyst Preparation, Poisoning and Regeneration of Catalysts.

Catalysis by Metals; Bulk *vs.* Supported Catalysts; Catalytic Materials – Molecular Sieves and Zeolites; Catalytic Materials - Mesoporous Materials; Catalytic Materials - Pillared Clays; Catalyst Preparation Techniques; Catalyst Characterization Techniques; Role of Surface Science in Catalysis; Catalytic Processes – Hydro cracking; Catalytic Processes – Hydro treating; Practical (Hydro treating Lab); Catalytic Processes - FCC/DCC; Catalysis for Clean Fuels – Photo catalysis; Catalysis for Clean Fuels – Electro catalysis; Catalysis for Clean Fuels – Fischer-Tropsch Catalysis; Catalysis for Clean Fuels – Methane to Hydrogen; Catalyst Deactivation, Poisoning, Sintering, Coke Formation and Regeneration; Catalytic Processes - Reforming, Isomerization and Alkylation

Practicals: Catalyst Characterization; Catalyst preparation; Hydro treating Lab; FCC Pilot plant; Reforming; GTL; Oxidation Catalysis.

Distribution of Lectures

Faculty	Designation	Number of Units
Prof D K Chakrabarty (Ext)	Ex IITB	10
Dr N Viswanadham	Principal Scientist	5
Dr R R Bal	Scientist	5
P Vijayanand	Principal Scientist	4
Dr A K Sinha	Principal Scientist	4
Dr S Tripathi	Scientist	4
Dr N Atheya	Senior Principal Scientist	3
Dr V V D N Prasad	Senior Scientist	2
Dr T V Rao	Senior Scientist	1

Course No: APST 704
L-T-P-C: 2-0-2-3
Course Title: Advanced Separation Processes-3 Credits
Course Coordinator: Dr A. Nanoti
List of Faculty: Dr A. Nanoti, Dr S. M. Nanoti, Dr M. O. Garg, Dr B. R. Nautiyal, Dr Soumen Dasgupta, Dr U C Aggarwal, Shri S. Divekar, Dr Asha Masohan (Ex-IIP), Dr Manoj Srivastava, Shri Sunil Kumar, Dr Sandip Biswas, Shri Manoj Thapliyal

Course Description :
Fundamentals of Separation Processes; Phase Equilibrium; Binary and multi-component separation; Multi stage separation processes; Equilibrium based separation processes; Rate based separation processes; Simulation of Separation processes; Capacity and efficiency of contacting devices; Energy requirements of separation processes; Selection of separation processes with case studies; Designing of Separation Processes; Special Topics in Adsorption: Adsorbents; Equilibrium Isotherms; PSA / TSA applications in Industry; Concepts of Simulated Moving Bed in Industrial applications; New developments in adsorbents; Adsorber simulations; Experiments in Adsorption: Hands on measurement of breakthrough curve of gas mixtures; adsorption equilbria in liquid systems: evaluation of equilibrium and kinetics data; characterization of adsorbents. Overview of Membrane Separation Processes; Gas separation membranes and Industrial applications.

Distribution of Lectures:

Faculty	Designation	No. of Units
Dr. Anshu Nanoti	Senior Principal Scientist	8
Dr. S. M. Nanoti	Chief Scientist	6
Dr. M.O.Garg	Director	5
Dr. B.R.Nautiyal	Senior Technical Officer (3)	5
Dr. Soumen Dasgupta	Scientist	4
Dr U. C. Aggarwal	Chief Scientist	2
Dr. Asha Masohan	Ex IIP	2
Dr. Manoj Srivastava	Senior Scientist	2
Shri Swapnil Divekar	Scientist	2
Shri Sunil Kumar	Scientist	2
Shri Sandip Biswas	Junior Scientist	1
Shri Manoj Thapliyal	Senior Techical Officer (1)	1

Course No: APST 705
L-T-P-C: 3-0-0-3
Course Title: Advanced Conversion Processes-3 credits
Course Coordinator: Dr G Das
List of Faculty: Dr G Das, Shri V K Kapoor (Ex IIP); Shri G. S. Dang (Ex IIP), Dr D. Tandon (Ex IIP), Dr S. M. Nanoti

Course Description
Isomerization; Catalytic Reforming; Hydro treating; FCC, DCC, RFCC; Hydro cracking; Thermal Conversion Processes; Visbreaking, Delayed Coking; Sweetening/Treating processes; Reactor design aspects – application to conversion processes; Residue up gradation; Residue gasification; Hydrogen production – Steam reforming.

Distribution of Lectures:

Faculty	Designation	Number of Units
Dr G Das	Senior Principal Scientist	14
Shri V K Kapoor	Ex IIP	16
Dr D Tandon	Ex IIP	4
Shri G S Dang	Ex IIP	5
Dr S M Nanoti	Chief Scientist	2

Course No: APST 604
L-T-P-C: 3-0-2-4
Course Title: Renewable Energy Conversion Technologies- 4 Credits
Course Coordinator: 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, Mr D V Naik, Mr 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, inter-conversions; 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 Units
Dr. Savita Kaul	Principal Scientist	12
Dr. T Bhaskar	Senior Scientist	7
Dr. D K Adhikari	Chief Scientist	5
Dr. Anil Sinha	Senior Scientist	3
DrAjay Kumar	Scientist	3
Dr.Neeraj Atray	Senior Scientist	3
Mr.D.V.Naik (Practical)	Scientist	3
Mr.Dinesh Bangwal (Practical)	Senior Technical Officer (3)	4

Course No: APST 501
Course Name: Research Methodology
L-T-P-C: 1-1-0-1

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 modeling and simulation; Design of experiment; Quantitative methods of data analysis; Qualitative analysis; Communicating Research results; Ethics in research. Case studies

Electives:

Faculty	Course No	Title	Credits
Dr T Bhaskar	APST 710	Hydro pyrolysis of Biomass	3
Dr Anil K Sinha	APST 711	Hydro processing	3
Dr N Viswanadham	APST 712	Gasoline Reformulation Techniques	3
Dr Bir Sain	APST 713	Value addition of Coker Streams	3
Dr J Singh	APST 714	Modeling Techniques in CFD	3
Dr S K Singhal	APST 715	Alternate Fuels	3
S K Ganguly	APST 716	Multiphase Reaction Kinetics	3

CSIR-IMMT

Materials Resource Engineering

Programme Description

The programme consists of two semesters of course work, one summer term of basic training on various research related skills, and two semesters of project-cum-thesis work.

Semester-wise Course Scheme

1st SEMESTER

S.N.	Course	Hours/ Week		Credits
		Lecture	Practical/ Tutorial	
1.	Technologies for mineral resource utilization	5	3	5
2.	Materials characterization technique	3	6	4
3.	Science for engineers	3	0	3
4.	Process control & instrumentation	3	3	3
			Total	15

2nd SEMESTER

S.N.	Course	Hours/ Week		Credits
		Lecture	Practical/ Tutorial	
1.	Advanced extraction methods	3	3	4
2.	Process design & simulation	3	3	4
3.	Fundamentals of engineering analysis	3	0	3
4.	Recycling of material resources	3	3	3
5.	Energy & environment	3	3	3
			Total	17

SUMMER TERM

1. Research Methodology (Compulsory)
2. Technical Writing and Communication (Compulsory)

3rd SEMESTER	**Credits**
1. Industrial interaction and research project planning	4
2. Seminar participation and presentation	4
4. Thesis work	8

4th SEMESTER	
1. Thesis work	16
Report preparation	
Seminar participation and presentation	
TOTAL CREDIT	**64**

Brief Course Outline

1. Technologies for Mineral Resource Utilization

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 applied to gravity, magnetic, electrostatic, and froth flotation processes

2. Process Design & Simulation

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.

3. Materials Characterization Technique

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.

4. Science for Engineers

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.

Structure and Bonding; Stereochemistry; Molecular basis of chemical reactions, reaction kinetics, structural effect on reactivity; Micelles and surfactants and their application for bulk processing of mineral resources; Complexation concepts, Molecular engineering; Chemical theories involved in solution, concentration, and purification.

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; Introduction to bio-mineral processing.

5. Recycling of Material Resources

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.

6. Fundamentals of Engineering Analysis

Formulation and solution of ordinary and partial differential equations that describe physical systems of importance in engineering; Numerical methods: finite difference, numerical solution of ordinary and partial differential equations.

Fundamental concepts of fluid flow, heat and mass transfer; Shell balance approach for molecular and convective transport processes; Formulation and application of general transfer equations.

7. Energy & Environment

Energy resources and conservation in different metallurgical processes; Renewable energy technologies; Energy audit with case studies.

Important Indian minerals and related environmental issues; Pollutant generation and management; Environmental issues related to mining, processing, and products; Environment impact analysis and management plan; Environmental laws—appraisal and approval; Vulnerability and adaptation technologies for sustainable development; Case studies related to environmental management of minerals and materials industries.

8. Advanced Extraction Methods

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.

9. Process Control & Instrumentation

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, PI Diagram, Introduction to PLC, SCADA & DCS, Networking and communication in industry, Artificial neural network & Fuzzy logic based control, Laboratory work.

SUMMER TERM COURSES (COMPULSORY)

10. Research Methodology

Definition and nature of research, Motivation for research, different types and styles of research in sciences, role of serendipity, scientific temperament, Working of some of the great minds from all walks of life--scientists, artists, writers, etc. Tools for thinking, critical and positive thinking, creativity and innovation, mind mapping; Development of problem solving skills, scaling and orders of magnitude analysis, role of simple models in thinking and in developing an understanding. Scientific and critical reasoning skills, art of reading and understanding scientific papers and critical evaluation of the underlying premises and assumptions, literature reviews. Professional attitudes and goals, concept of excellence, ethics in science and engineering, some famous frauds in science.

11. Technical Writing & Communication Skills

Technical vis-a-vis literary writing, Ethical and legal considerations, Writing process, Collaborative writing, Analyzing audience and purpose, Communicating persuasively, Researching the subject and reference, Organizing information, Drafting definitions and descriptions, coherent text, effective sentences, front and back matter, Designing of documents and familiarization with standard styles, Creating graphics, Writing journal paper, thesis, project proposal, report, technical note, letter, memo, resume, manual, Website design and using software based publishing, Seminar and oral presentations.

CSIR-NCL

Chemical Engineering- Advanced modeling and simulation
Advanced Materials and Processes

Program Description

The academic program comprises of 10 subject courses, lab courses, research proposal course, seminar and symposium participation, and the research project, for a total of 80 credits. One credit approximately corresponds to 15 faculty-student contact hours. In addition, students are expected to spend approximately twice that time in self-study, assignments, and course projects. Evaluations are biased towards a continuous mode, with at least half the total marks assigned for performance in classroom tests, and homework assignments. There will be a mid-semester and end-semester exam at defined times, which may also be in the open-book or take-home format. Emphasis will be on understanding and implementation rather than accumulation of facts.

Semester I

The first semester comprises of five courses that form the core courses in the program.

Summary

S. No.	Subject	Code	Credits (L-T-P-C)
1	Mathematical fundamentals	ChE601	3-1-0-4
2	Reaction and reactor engineering	ChE602	3-1-0-4
3	Transport phenomena	ChE603	3-1-0-4
4	Thermodynamics and statistical mechanics	ChE604	3-1-0-4
5	Numerical methods and programming	ChE605	3-1-0-4
6	Seminar Participation	ChE651	3-1-0-4

Semester II

The second semester comprises of specialized courses that introduce the student to specific areas. Students will have the option of choosing courses worth 16 credits to fulfill their course credit requirements. In addition, the student is supposed to present a research seminar.

Summary

S. No.	Subject	Code	Credits
1	Multiscale simulations in materials	ChE611	3-1-0-4
2	Industrial flow modeling	ChE612	3-1-0-4
3	Data driven modeling	ChE613	2-0-0-2
4	Non-linear system dynamics	ChE614	2-0-0-2
5	Modeling of biological systems	ChE615	3-1-0-4
6	Advanced Separations	ChE616	2-0-0-2
7	Advanced topics in materials and processes	ChE701	2-0-0-2
8	Advanced topics in chemical engineering science	ChE702	2-0-0-2
9	Critical Survey	ChE641	0-4-0-2
10	Seminar Participation	ChE652	0-1-0-1

Semesters III and IV

The third and fourth semesters will involve research with a scientist-mentor. Co-advised projects, or projects with both experimental and modeling/simulation components may be offered. The student is expected to work in the scientist's lab and interact with him/her daily. There will be periodic evaluations, with detailed reports on the progress of the project and plans for future work to be presented to either the instructor or a committee, who will evaluate the candidate based on the report and an oral presentation. In addition, students are expected to register for three lab courses, the NCL Research Methodology course and seminars.

Semester III

S. No.	Subject	Code	Credits
1	Lab- Reactors	ChE631	0-0-4-2
2	Lab- Biochemical	ChE632	0-0-4-2
3	Lab- Materials	ChE633	0-0-4-2
4	Lab- Advanced Analytics	ChE634	0-0-4-2
5	Seminar Participation	ChE653	0-1-0-1
6	Project evaluation I	ChE691	0-12-0-12

Semester IV

S. No.	Subject	Code	Duration
1	Research Methodology	NCL501	2-0-0-2
2	Project evaluation II	ChE693	0-8-0-8
3	Final Project evaluation	ChE694	0-12-0-12
4	Seminar Participation	ChE654	0-1-0-1

Total credits for NCL's PGRPE program = 80 (44 classroom/lab teaching, 32 thesis, 4 others)

Coursework details

NCL501: Research Methodology **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

ChE601: Mathematical fundamentals **4 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

CHE610: Numerical Methods and Programming **4 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

CHE603: Transport phenomena **4 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

CHE604: Thermodynamics and Statistical Mechanics **4 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

CHE602: Reaction and Reactor Engineering **4 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

CHE611: Multiscale simulations in materials **4 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

CHE612: Industrial flow modeling **4 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

CHE613: Data driven modeling **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.

CHE614: Non-linear dynamics **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

CHE615: Modeling of biological systems **4 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

CHE616: Advanced separation processes **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

CHE701: Advanced topics in materials and processes **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.

CHE702: Advanced topics in chemical engineering science **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.

CHE631-634: Lab courses **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.

CHE651-ChE658: Seminar Participation **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.

CHE641 and ChE642: Research Proposal I and Research Proposal II **02 x 2 =4 credits**

Course Objective

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

CHE661: Symposium participation **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.

Faculty Profiles

Name/Contact details	Education and Experience	Research Interests
Dr. Amol A. Kulkarni Scientist NCL Phone: 020-25902153 E-mail: aa.kulkarni@ncl.res.in 	• IUSSTF Research fellow, MIT, Cambridge, USA • Postdoctoral fellow, MPI for Dynamics of Complex Systems, Magdeburg, Germany • Ph.D., (Chemical Engineering), M. Chem. Eng., B. Chem. Engg. Inst. of Chem. Technology (ICT, formerly UDCT).	• Microreaction technology: micro-fluidics, design of miniaturized devices, modelling and experimentation. • Continuous flow synthesis of API, nanoparticles and azo colorants • Experimental and computational fluid dynamics • Nonlinear dynamics • Development of data analysis techniques for nonlinear and non-stationary data
Dr. Anu Raghunathan Scientist, NCL Phone: 020-25903067 Email: anu.raghunathan @ ncl.res.in 	• Faculty (Research), Mount Sinai (Medicine), NY • Post doctoral Fellow, Bioengineering, University of California San Diego • Post Doctoral Fellow, Microbiology and Cell Science, Univ of Florida • Ph.D., Chemical Engineering, IIT Bombay • M.S., Analytical and Medicinal Chemistry, SNDT, Mumbai	• Metabolic network reconstruction and constraints based analysis of biological systems • Microbial strain design for use of renewable resources, systems biology and molecular adaptation to produce and improve yields. • Drug Target Discovery: Systemic approaches (computational and experimental) to study metabolism in pathogenesis to discover novel drug targets.
Dr Ashish Lele Scientist, NCL Phone:020-25902199 Email: ak.lele@ncl.res.in 	• Research Associate, University of Cambridge • Ph.D., Chemical Engineering, University of Delaware, USA • B.Chem.Eng., University of Mumbai, Department of Chemical Technology (UDCT)	• Rheology of complex fluids such as polymer melts, associating polymer solutions and soft solids. • Developing coarse-grained models for polymer dynamics and using them to quantify the processing behavior of melts in complex flows by a combination of CFD simulations and experimental validation. • Structure-property relations in physical gels
Dr. Ashish Orpe Scientist, NCL Tel: 020-25902749 Email: av.orpe@ncl.res.in 	• Postdoctoral Research Associate, (2004 – 2007), Department of Physics, Clark University, MA, USA • Ph.D., Chemical Engineering, (2004), IIT Bombay, Mumbai, India • M.Tech., Chemical Engineering, (1998), IIT Bombay, Mumbai, India • B. E., Petro-Chemical Engineering, Univ. of Pune,	• Micro-rheology of dense, sheared granular media, study of mixing behaviour, pattern formations in flowing dry/cohesive powders • Flow dynamics, instability and finger formations in a spreading non-Newtonian liquid, suspensions under the influence of gravity or centrifugal forcing • Transport of slurries, flow through porous media

Name/Contact details	Education and Experience	Research Interests
Dr B. D. Kulkarni Scientist, NCL Phone:020-25902150 Email: bd.kulkarni@ncl.res.in 	• PhD, Chemical Engineering, University of Pune • M. Tech, Chemical Engineering, LIT, Nagpur • B Tech Chemical Engineering, LIT Nagpur	• Chemical reaction engineering • Mathematical modeling • Optimisation and control • Process design • Fluidization • Microemulsions/ micelles
Dr Chetan Gadgil Scientist, NCL Phone: 020-25902163 Email: cj.gadgil@ncl.res.in 	• Investigator, GlaxoSmithKline, USA • Postdoctoral research associate, School of Mathematics, U. Minnesota • Ph.D., Chemical Eng, Univ. of Minnesota, USA • M Tech, Chemical Engineering, IIT Bombay • B. Chem. Eng. ICT (formerly UDCT), Mumbai.	• Mechanistic models of biological systems: regulatory networks, other cellular processes • Modeling/Simulation of patterning in biology • Stochastic models for (bio) chemical reactions • Modeling drug delivery and distribution kinetics
Dr. K. Guruswamy Scientist, NCL Phone: 020-25902182 Email: g.kumaraswamy@ ncl.res.in 	• Postdoctoral fellow, Max Planck Institute for Colloids and Interfaces, Germany • Ph.D., Chemical Engineering, California Institute of Technology, USA. • M.S., Chemical Engineering, California Institute of Technology. • B.Tech., Chemical Engineering, Indian Institute of Technology, Bombay.	• Synthesis and assembly in anisotropic liquid crystal matrices • Plate-like anisotropic nanoparticles – self-assembly & nanocomposites • Rheology and structure of two-phase (crystallizing) polymer melts
Dr Kumar Vanka Scientist, NCL Phone: 020-25902083 Email: k.vanka@ncl.res.in 	• Postdoctoral fellow, (CEBC), Kansas University • Ph.D., Chemistry, University of Calgary, Canada. • M.Sc., Chemistry, University of Calgary. • BSc. Chemistry, Indian Institute of Technology, Khargapur.	• Determining catalytic routes to hydrogen storage • Finding better catalysts for asymmetric hydroformylation • Stochastic methods to study changes in reactant-product concentrations • Determining the principles behind polymer formation using Ziegler-Natta heterogeneous catalysts

Name/Contact details	Education and Experience	Research Interests
Dr Leelavati Narlikar Ramanujan Fellow, NCL Phone:020-25903076 Email: l.narlikar@ncl.res.in	• Research Associate, Centre for Modeling and Simulation, Pune University • Postdoctoral Fellow, National Insititutes of Health, MD, USA • PhD, Computer Science, Duke University, 2008 • BE, Computer Engineering, Pune University, 2002	• Machine learning: Supervised and unsupervised learning from large scale data; Bayesian modeling; Statistical optimization algorithms • Computational biology: Identifying gene regulatory elements; Mapping networks of transcriptional regulation; Understanding the role of epigenetics in regulation
Dr Mugdha Gadgil Scientist, NCL Phone:020-25902433 Email: mc.gadgil@ncl.res.in 	• Scientist, Invitrogen Corporation, MD, USA • Postdoctoral research associate, University of Minnesota, MN, USA • Ph.D., Chemical Eng, University of Minnesota, MN, USA, 2004. • B. Chem. Eng. ICT (formerly UDCT), Mumbai, 1999.	• Bioinformatics: developing methods for analysis of DNA microarray data • Bioprocess engineering for cell culture processes
Dr Neelanjana Sengupta Scientist, NCL Phone: 91-20-25902087 Email: n.sengupta@ncl.res.in 	• PhD, Physical Chemistry, Univ. of California, Irvine, 2008 • M.S, Chemical & Materials Physics, Univ. of California, Irvine, 2007 • M.Sc., Physics, Univ. of Burdwan, 2000 • B.Sc., Physics, Univ. of Burdwan, 1998	• Understanding amyloid formation and protein aggregation diseases • Protein translocation through membranes • Solvent dynamical coupling in biomolecules • Transport and signaling phenomena in biomolecular confinement
Dr. Pankaj Doshi Scientist, NCL Tel: 91 20 25903074 Email: p.doshi@ncl.res.in 	• Principal Scientist, Pfizer Inc., USA • Investigator, GlaxoSmithKline, USA • Postdoctoral researcher, MIT, Cambridge, MA, USA • PhD, Chemical Engineering Purdue University • M.Tech., Chemical Engineering IIT Bombay • B.Tech., Chemical Engineering IIT Bombay	• Numerical Simulation of free surface flow of Newtonian and non-Newtonian fluids: Finite element method, Steady and Time dependent simulation, Parallel Computing; Interfacial flows; Study of inkjet printing, liquid drops and jets • Computational models, design and optimization of Dry Powder Inhaler, design of novel drug formulations • Mathematical models for design, control and optimization of pharmaceutical unit operations

Name/Contact details	Education and Experience	Research Interests
Dr. Rajnish Kumar Scientist, NCL Tel: 91 20 25902734 Email: k.rajnish@ncl.res.in 	• Postdoctoral fellow, National Research Council Canada, Canada • Research Engineer, Sterlite Industries (I) Ltd., India • Ph.D., Chemical Engineering, University of British Columbia, Canada. • M.S., Chemical Engineering, Indian Institute of Science, India • B. E., Chemical Engineering, Pt. Ravishankar Shukla University, Raipur, India	• Gas Hydrates (Formation, Inhibition & Recovery) • Carbon Dioxide capture, storage and utilization • Hydrogen Storage materials • Chemical Reactions and Extractions in Supercritical Fluids • Process Scale-up
Dr. V. Ravi Kumar Scientist, NCL Tel: 91 20 25902161 Email: v.ravikumar@ncl.res.in 	• Postdoctoral Research Associate, (1984 -1986), Department of Chemical Engineering, Texas A&M University, TX, USA • Ph.D., Chemical Engg. Division, National Chemical Laboratory & University of Pune, India • M.Sc., Chemistry Dept., Bangalore University , (1978)	• Nonlinear dynamics, chaos and turbulence • Chemical reaction engineering • Analysis of complex systems and networks • Parameter estimation, optimization and control • Noise reduction in nonstationary data by multiresolution techniques • Studying data classification, pattern formation and feature extraction from space-time data obtained from experimental systems
Dr. Sanjeev Tambe Scientist, NCL Tel: 91 20 25902156 Email: ss.tambe@ncl.res.in 	• Visiting Scientist, Department of Chemical Engineering, University of Louisville, KY, USA. • Research Associate at Department of Geology, University of Louisville, Louisville, KY, USA. • Ph.D., (Physical Chemistry) NCL & Univ. of Bombay • M. Sc. (Analytical Chemistry) Department of Chemistry, University of Bombay	• Design, development and application of Artificial Intelligence and machine learning formalisms to chemical and biological systems. • Modeling and optimization of reactions/reactors; control and analysis of nonlinear systems • Chemical reactor/reaction modeling via phenomenological, stochastic, cellular automata, and Monte Carlo approaches • Applications of fractal theory and multi-variate statistics.

Name/Contact details	Education and Experience	Research Interests
Dr. Sourav Pal, Scientist, NCL Phone: 9120 2590 2001 Email: s. pal@ncl.res.in 	• Post-doctoral research associate at University of Florida 1986-87 • Alexander von Humboldt Fellow, University of Heidelberg, Germany 1987-88 and several short periods subsequently • Ph D, IACS, Kolkata, 1983 • M Sc (5 years' Integrated) in Chemistry, IIT, Kanpur, 1977	• Electronic Structure theory for properties on spectra • Development of linear response formalism for effective Hamiltonian based theories. • Conceptual DFT for description of reactivity in molecules • Computational material science for catalytic properties of zeolites • Theoretical study of hydrogen storage properties of metal hydrides/ MOFs
Dr Sudip Roy Scientist, NCL Phone: 91-20-25902735 Email: s.roy@ncl.res.in 	• Postdoctoral Fellow; Technical University Darmstadt, Germany • Ph.D., Chemistry, Saarland University, Germany • M.Sc., Visva Bharati Central University, West Bengal • BSc. Visva Bharati Central University, West Bengal	• Prediction of macroscopic properties from molecular and mesoscopic scale simulations • Multiscale method development • Force field development and optimization for new systems for molecular dynamics simulations • Coarse graining of polymers and bio-molecules to simulate long time and larger length scale phenomena
Dr Vivek V Ranade Scientist, NCL Phone:91-20-25902170 Email: vv.ranade@ncl.res.in 	• Research Associate, ETH Zurich, 1988-90 • Ph.D., Chemical Engineering, University of Mumbai, Department of Chemical Technology (UDCT), 1988. • B. Chem. Eng., University of Mumbai, Department of Chemical Technology (UDCT), 1984	• Multiphase reactor engineering. • Developing multi-scale models to simulate large industrial flow processes/ Industrial flow modeling. • Developing methodology for bridging the gap between capabilities of state of the art mathematical models and industry requirements • Turbulent, multiphase flows/ phase change

CSIR-NEERI

Environmental System Engineering & Modelling

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE, NAGPUR

M.Tech (Environmental System Engineering & Modelling)

Subjects Marked 1 to 6 in I and II semester are compulsory. Students are required to choose from electives one or two subjects from electives in IIIrd Semester

Sl. No.	Code No.	Course Title	L	T	P	C	Faculty
		Semester I					
1	**ENG(NEERI)-1-001**	Research Methodology, Ethics, Communication skills, lab safety	1	1	-	2	Mr. P.S. Dutt
2	ENG(NEERI)-2-731	Advanced Engineering Mathematics and Numerical techniques	2	1	-	3	Dr. Mrs. A. Sargaonkar
3	ENG(NEERI)-2-732	Optimisation Techniques	3	-	-	3	Dr. Rajesh Binniwale
4	ENG(NEERI)-2-733	GIS & Remote Sensing Techniques (+Lab)	2	-	2	3	Mr. Ritesh Vijay
5	ENG(NEERI)-2-734	Basic principles of Environmental Systems (+ Lab)	2	-	2	3	Mr. P.S.Dutt & Dr. R.A.Sohony
6	ENG(NEERI)-2-735	Environmental Chemistry & Microbiology(+Lab)	2	-	2	3	Dr.R.J. Krupadam&Dr. Prince Williams
		Semester II					
1	ENG(NEERI)-2-736	Ecosystems Dynamics	3	-	-	3	Dr. Mrs. A. Juwarkar
2	ENG(NEERI)-2-737	Air and Noise Quality Control Management	2	-	2	3	Dr. S.K. Goyal
3	ENG(NEERI)-2-738	Design of Water and Wastewater System	2	1	-	3	Dr. N.S.Raman
4	ENG(NEERI)-2-739	Solid and Hazardous Waste Management	2	-	2	3	Dr. S.Y.Bodhke
5	ENG(NEERI)-2-740	Environmental Impact and Risk Assessment (Field visit)	2	1	-	3	Dr.TVBPS Ramakrishna
6	ENG(NEERI)-2-741	Environmental Systems Modelling & Optimization (+Lab)	2	-	2	3	Dr. R.A.Sohony
		Semester III					
1	ENG(NEERI)-2-742	One Elective Course from the list	2	-	2	3	
2	ENG(NEERI)-2-743	Seminar on Research Theme					
		Semester IV					
1	ENG(NEERI)-2-744	Thesis work, Seminar and Report writing					
		ELECTIVES					
1	ENG(NEERI)-2-745	Environmental Genomics (+Lab)	2	-	2	3	Dr. H.J.Purohit
2	ENG(NEERI)-2-746	Data Analysis and Parameter Estimation	2	1	-	3	Dr. Mrs. A. Lalwani
3	ENG(NEERI)-2-747	Design of Environmental Monitoring System & Instrumentation (+ Lab)	2	-	2	3	Dr. Mrs. N.P.Thacker
4	ENG(NEERI)-2-748	Water Resource Management (+Lab)	2	-	2	3	---
5	ENG(NEERI)-2-749	Climate Change	3	-	-	3	Mr. P.S.Dutt
6	ENG(NEERI)-2-750	Environmental Economics, Policy and Law (Seminar)	2	-	2	3	Mr. P.S.Dutt
7	ENG(NEERI)-2-751	Materials and Environmental Applications (+Lab)	2	-	2	3	Dr. Mrs. S. Rayalu
8	ENG(NEERI)-2-752	Bioremediation (+Lab)	2	-	2	3	Dr. Mrs. A. Juwarkar
9	ENG(NEERI)-2-753	Advanced Treatment Systems	3	-	-	3	Dr. S.Y.Bodhke
10	ENG(NEERI)-2-754	Energy & Environment	3	-	-	3	Dr. N.Labhasetwar

M.Tech. (Environmental Engineering & Modelling) Course Details

ENG(NEERI)-2-735	Environmental Chemistry & Microbiology	2	-	2	3

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp) ,heavy metal precipitation, amphoteric hydroxides,CO_2 solubility in water and species distribution – Chemical kinetics , First order, Colloids, electrical properties, double layer theory, environmental significance of colloids,coagulation.

Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals-Metals, complex formation, oxidation and reduction , Eh – pH diagrams, redox zones, Fe – sorption-Chemical speciation-

Atmospheric structure –-chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO_2 capture – Acid rain-origin and composition of particulates. Air quality parameters-effects and determination

Nature and composition of soil-Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – Reclamation of contaminated land.

Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, Preservation of microorganisms, DNA, RNA, replication, Recombinant DNA technology.

Distribution of microorganisms – Distribution / diversity of Microorganisms – fresh and marine, terrestrial – microbes in surface soil, Air – outdoor and Indoor, aerosols, biosafety in Laboratory – Extreme Environment – archaebacteria – Significance in water supplies – problems and control. Concentration and detection of virus, Transmissible diseases.

Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Kreb's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, Bioenergetics.

Transmission of pathogens – Bacterial, Viral, Protozoan, Indicator organisms of water – Coliforms - total coliforms, E-coli, Streptococcus, Clostridium, Control of microorganisms; Microbiology of biological treatment processes – aerobic and anaerobic, α -oxidation, β-oxidation, nitrification and denitrification, eutrophication.

Factors influencing toxicity. Effects – acute, chronic, concentration response relationships. Test organisms – toxicity testing, Bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching.

ENG(NEERI)-2-736	Ecosystems Dynamics	3	-	-	3

A brief history; Concept, and major branches *Concept of Speciation:* Types and process *Extinction:* A brief history and reasons

Community Ecology: Concept, Characteristics and dynamics; Interactions; Developmentof community (Plant Succession); Parasitism; Prey-Predator relationship

Population Ecology: Characteristics of population; Dynamics and Interactions;Regulation; Population genetics

Aquatic Ecosystem: Fresh water and Marine system, their types, characteristics and components; Wetlands, their Significance and conservation, Eutrophication and remedial measures

***Terrestrial ecosystems*:** Major terrestrial biomes - Forest, Desert, and Grassland (a brief account); Relationship between Precipitation and temperature in determining the vegetation; Forest Types of India (a concise account)

Biological Invasion: Concept; Pathways of Invasion; Process of Invasion; Mechanism of Invasions; Impact of Invasive Species - Ecological, Environmental, Economical; Some examples of major invasive plants and animals in India

Sustainable Development: The Concept and strategies of sustainable development

Biodiversity: Definition; levels of diversity; alpha, beta and gamma diversity, and their measurement; '*Biodiversity Hotspots'* **–** concept and a brief account; Biodiversity hotspots of India: a short account; Concept of **e**ndangered and threatened species: IUCN Categories of Extinction; Names of a few endangered and threatened animals and plants (of India); Strategies for biodiversity conservation: Concept of Protected Area Networks -National Parks, Wildlife Sanctuaries, Biosphere Reserves (A brief account)

ENG(NEERI)-1-001	Research Methodology, Ethics, Communication skills, lab safety	1	1	-	2

Quantitative methodology

Application of statistical concepts/procedures. Graphs, numerical summaries. Normal distribution, correlation/regression analyses, probability, statistical inferences for one or two samples. Hypothesis tests, Chi-square tests. Conceptual understanding/application of statistics. Application of statistical concepts/procedures. Analysis of variance, covariance, multiple regression. Experimental design: completely randomized, block, split plot/repeated measures.

Advanced theory, derivations of quantitative statistics. Descriptive statistics, probability, normal distribution. One-/two-sample hypothesis tests, confidence intervals. Chi square tests. One-way analysis of variance, follow up tests.

Analysis of variance designs (two-/three-way), repeated measures, correlation, simple/multiple regression methods, non-parametric procedures, multivariate analyses.

Qualitative methodology

Application of Critical Discourse Analysis methods to analysis of written, visual, and spoken texts in social settings such as schools, families, and communities.

Introduction to use of qualitative research methods. Ethnography, sociolinguistics, symbolic interactionism. Emphasizes observation.

How to code/analyze field notes. Individual/group interviews, Students interpret analyzed material and complete an article length document that includes a review of related research/methodology.

Applications containing designing studies that employ open-ended interviewing as primary data collection technique.

Practice in aspects of field methodology below the level of full field study; detailed reading; analysis.

Application of interpretive research. Practice in conducting interpretive research in work.

Origins, influences, characteristics, and central concepts; distinction between critical science and other action research; requisite skills and knowledge for conducting critical science research and using that knowledge in a project.

Combined methods

Introductory course in program evaluation; planning an evaluation study, collecting and analyzing information, reporting results; overview of the field of program evaluation.

Survey methods, Principles of measurement, constructing questions/forms, pilot testing, sampling, data analysis, reporting. Students develop a survey proposal and a draft survey, pilot the survey, and develop sampling/data analysis plans.

Discourse processes in dyadic and multiparty conversation. Application of concepts through analysis of conversations.

Transcribing and analyzing verbal communication and movement related to it. Applying concepts to recorded conversations.

Logic of communication theory development and modification from a social scientific perspective. Types of communication theories.

Alternately Simplified Topics are as follows;

- Creativity and out of box thinking
- Science and technology system and planning in India, planning for science and technology (5 yr plan)
- Basics of statistics (why statistics, laws, uncertainties, inferences).
- Planning of experiments, principles of design, and requirements for a good experiment.
- Quality of measurement, factorial experiments.
- Intellectual property fundamentals.
- Response surface methodology.
- Searching scientific information, popular science writing (language and style).
- Introduction to writing scientific papers.
- Research methodology, Method of science
- Project management (PERT, CPM)

ENG(NEERI)-2-734	Basic principles of Environmental Systems (+ Lab)	2	-	2	3

Structure and basic properties of water - their significance in environment engineering, sources of water impurities, abiotic reactions, biological metabolism. Solid-liquid-gas interactions, mass transfer and transport of impurities in water and air, diffusion, dispersion. Physical and Chemical interactions due to various forces, suspensions and dispersions. Chemical reactions, chemical equilibrium and chemical thermodynamics, acid-base equilibria, solubility equilibria, oxidation-reduction equilibria. Process kinetics, reaction rates and catalysis, surface and colloidal chemistry, adsorption. Settling of particles in water, coagulation and flocculation, filtration - mechanisms and interpretations, ion exchange and adsorption, water stabilization, aeration and gas transfer, Membrane processes; reverse osmosis, electrodialysis, desalination.

Ecosystems; biotic and abiotic components, production and consumption, trophic levels, productivity and energy flow, food webs, cycling of elements. Ecology of population; ecological niche, mortality and survivorship, community interactions. Changes in ecosystems; succession. Long range changes, long range stability. The organization and dynamics of ecological communities. Description and study of typical natural and artificial ecosystems. Biochemistry; photosynthesis and respiration, important biological compounds, enzymes. Microbiological concepts; cells, classification and characteristics of living organisms, characterization techniques, reproduction, metabolism, microbial growth kinetics. Applications to environmental engineering; assimilation of wastes, engineered systems, concepts and principles of carbon oxidation , nitrification, denitrification, methanogenesis, etc., concepts of quantification of degradable pollutants.

ENG(NEERI)-2-731	Advanced Engineering Mathematics and Numerical techniques	2	1	-	3

Applications of differentiation:– Definition of Hyperbolic functions and their derivatives- Successive differentiation- Leibnitz' Theorem(without proof)- Curvature- Radius of curvature- centre of curvature- Evolute (Cartesian ,polar and parametric forms) Partial differentiation and applications:- Partial derivatives- Euler's theorem on homogeneous functions- Total derivatives- Jacobians- Errors and approximations- Taylor's series (one and two variables) - Maxima and minima of functions of two variables - Lagrange's method- Leibnitz rule on differentiation under integral sign. Vector differentiation and applications :- Scalar and vector functions- differentiation of vector functions-Velocity and acceleration- Scalar and vector fields- Operator ∇ - Gradient- Physical interpretation of gradient- Directional derivative- Divergence- Curl- Identities involving ∇(no proof) - Irrotational and solenoidal fields – Scalar potential.

Laplace transforms:- Transforms of elementary functions - shifting property- Inverse transforms- Transforms of derivatives and integrals- Transform functions multiplied by t and divided by t - Convolution theorem(without proof)-Transforms of unit step function, unit impulse function and periodic functions-second shifiting theorem- Solution of ordinary differential equations with constant coefficients using Laplace transforms.

Differential Equations and Applications:- Linear differential eqations with constant coefficients- Method of variation of parameters - Cauchy and Legendre equations – Simultaneous linear equations with constant coefficients- Application to orthogonal trajectories (cartisian form only).

Matrices:-Rank of a matrix- Elementary transformations- Equivalent matrices- Inverse of a matrix by gauss-Jordan method- Echelon form and normal form- Linear dependence and independence of vectors- Consistency- Solution of a system linear equations-Non homogeneous and homogeneous equations- Eigen values and eigen vectors – Properties of eigen values and eigen vectors- Cayley Hamilton theorem(no proof)- Diagonalisation-Quadratic forms-Reduction to canonical forms-Nature of quadratic forms-Definiteness,rank,signature and index.

ENG(NEERI)-2-737	Air and Noise Quality Management Control	2	-	2	3

Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution – Sources and classification of air pollutants and their effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards – Air Pollution Indices – Emission Inventories – Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories – Dispersion models, Software application, Plume rise, Effective stack height .

Factors affecting Selection of Control Equipment – Gas Particle Interaction, – Working principle, Design and performance equations of Gravity Separators (cyclone) , Centrifugal separators Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations - Process Control and Monitoring – Costing of APC equipment – Case studies for stationary and mobile sources.

Factors affecting Selection of Control Equipment – Working principle, Design and performance equations of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters – Process control and Monitoring - Operational Considerations - Costing of APC Equipment – Case studies for stationary and mobile sources.

Sources and Effects of Noise Pollution – Measurement – Standards –Control and Preventive measures

ENG(NEERI)-2-738	Design of Water and Wastewater System	2	1	-	3

Water treatment concepts; pretreatment, primary treatment, secondary treatment, tertiary treatment. Water quality standards; characteristics. Theory and design of physicochemical unit operations; screening, grit, removal equalisation, sedimentation, floatation, caogulation-flocculation, filtration, disinfection, membrane processes, desalination, ion-exchange,

aeration/gas transfer, precipitation, adsorption. Hydraulics of treatment plant; flow measurement and hydraulic control points, hydraulic analysis of unit operations, hydraulic profile through the treatment plant.
Wasterwater treatment concepts; pretreatment, primary treatment, secondary treatment, tertiary treatment. Water quality standards; characteristics. Theory and design of physicochemical unit operations; screening, grit, removal equalisation, sedimentation. Theory and design of biological unit operations; aerobic and anaerobic processes; Aerobic unit operations for organic carbon removal such as activated sludge, tricling filter, oxidation ditch, oxidations ponds, aerated lagoons, root zone treatment, vermifilter etc. Anaerobic operations for organic carbon removal such as UASB, filters, fluidised/expanded bed systems etc. Biological unit operations for nitrogen and phosphorus removal. Theory and design of Sludge treatment, sludge thickening, sludge drying, incineration, aerobic and anaerobic digestion of sludges. Theory and design of wastewater disposal and systems;disposal to inland water bodies, sea/ocean disposal; land/underground disposal.

ENG(NEERI)-2-739 Solid and Hazardous Waste Management 2 - 2 3

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes , plastics and fly ash – Financing waste management.
Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse
Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport
Objectives of waste processing – material separation and processing technologies – biological and chemical conversion technologies – methods and controls of Composting - thermal conversion technologies and energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes

Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

ENG(NEERI)-2-740 Environmental Impact and Risk Assessment 2 1 - 3

To expose the students to the need, methodology, documentation and usefulness of environmental impact and risk assessment and to develop the skill to prepare environmental management plan. Also it will students understand and discuss the basics of risk assessment, risk management

Historical development of Environmental Impact Assessment (EIA). EIA in Project Cycle. Legal and Regulatory aspects in India. – Types and limitations of EIA – Cross sectoral issues and terms of reference in EIA – Public Participation in EIA. EIA process- screening – scoping - setting – analysis – mitigation

Matrices – Networks – Checklists – Connections and combinations of processes - Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological –– Cumulative Impact Assessment – Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation. EIA methods in other countries.

Definition of social impact assessment. Social impact assessment model and the planning process. Rationale and measurement for SIA variables. Relationship between social impacts and change in community and institutional arrangements. Individual and family level impacts. Communities in transition - neighborhood and community impacts. Selecting, testing and understanding significant social impacts. Mitigation and enhancement in social assessment. Environmental costing of projects.

Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – Post project audit – Ethical and Quality aspects of Environmental Impact Assessment.

EIA related to the following sectors - Infrastructure –construction and housing Mining – Industrial - Thermal Power - River valley and Hydroelectric – coastal projects-Nuclear Power. EIA for coastal projects.

Concept of risk, objective and scope of risk assessment, probabilistic risk, risk perception and acceptability. Quantitative aspects of risk. Three levels of risk quantification, PRA management, preliminary hazard analysis, HAZOP and HAZAN, FMEA and FMECA analysis, Fault tree Analysis. Digraph and other approaches. Computation of Hazard probability, unavailability and other parameters using fault tree methodology. Monte Carlo Simulation technique, Event tree analysis, identification of initiating events, sequence and scenario development, system analysis, external events and dependent failure analysis and quantification, Accident-consequence Analysis, uncertainty analysis, sensitivity analysis and importance measures. Bayesian approaches. Human reliability Analysis.

ENG(NEERI)-2-747	Design of Environmental Monitoring System & Instrumentation	2	-	2	3

Wet Chemistry methods and their limitations-Instrumental Methods, Selection of method-Precision and Accuracy, Error in measuring signals- Quality control & assurance- Sample preservation, Sample preparation and analyte isolation.

Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry (Flame, graphite furnace and hydride generation), Atomic Emission Spectrometry (AES) , flame and Inducted Coupled Plasma (ICP) – TOC Analyzer

Column, Paper and thin layer chromatography (TLC)- Principles, techniques and applications of GC, GC-MS, High performance liquid chromatography (HPLC) and Ion chromatograph (IC)-Hyphenated techniques for Environmental contaminant(trace organics) analysis.

Principles, techniques and applications of Conductometry, potentiometry, coulometry, AOX analyzer Amperometry, polarography, New Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.

Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NOx Fluorescent analyzer for SO2- Particulates analysis- Auto analyzer for water quality using flow injection analysis.

ENG(NEERI)-2-732	Optimisation Techniques	3	-	-	3

Historical Development, Engineering application of Optimization, Formulation of design problems as mathematical programming problems, classification of optimization problems.
Linear Programming: Graphical method, Simplex method, Revised simplex method, Duality in linear programming (LP), Sensitivity analysis, other algorithms for solving LP problems, Transportation, assignment and other applications.
Non Linear Programming: Unconstrained optimization techniques, Direct search methods, Descent methods, Constrained optimization, Direct and indirect methods, Optimization with calculus, Khun-Tucker conditions.
Dynamic Programming: Introduction, Sequential optimization, computational procedure, curse of dimensionality,
Advanced Techniques of Optimization: Introduction, Genetic algorithms for optimization and search.

ENG(NEERI)-2-750 Environmental Economics, Policy and Law (Seminar) 2 - 2 3

Broad aspects of environmental economics; society and environment, sustainable development, management of environment, regional and global environmental strategies, environmental movements. Environmental legislation; role of U.N. and its associate bodies, role of world bank, administering global environmental funds, environmental programmes and policies in developed and developing countries, environmental programmes and policies of the government of India, structural changes for environmental managements, sectoral policies regarding land, water, forestry, energy, industrial pollution, and human resources development. Environmental impact assessment (EIA); rationale and historical development of EIA, methodologies and socio-economic aspects of EIA, status of EIAs in india, case studies stressing socio-economic aspects of EIA. Planning Levels, physical planning and development Cost-Benefit analysis, methods of economic evaluation of intangible environmental resources; contingent method, travel cost, opportunity cost concept of consumer behaviour, environmental consumerism

ENG(NEERI)-2-741 Environmental Systems Modelling & Optimization 2 - 2 3

Water and air quality management - Role of mathematical models; systems approach - systems and models - kinds of mathematical models - model development and validation effluent and stream standards; ambient air quality standards. Historical development of water quality models ; rivers and streams water quality modelling - river hydrology and flow - low flow analysis - dispersion and mixing - flow, depth, and velocity - estuaries - estuarine transport, net estuarian flow, estuary dispersion coefficient; Lakes and impoundments - water quality response to inputs; water quality modeling process - model sensitivity - assessing model performance ; Models for dissolved oxygen, pathogens; Streeter - Phelps models.
Transport and dispersion of air pollutants - wind velocity, wind speed and turbulence; estimating concentrations from point sources - the Gaussian Equation - detemination of dispersion parameters, atmospheric stability; dispersion instrumentation - Atmospheric traces; concentration variation with averaging time; Air pollution modelling and prediction - Plume rise, modelling techniques, modelling for nonreactive pollutants, single source - short term impact; multiple sources and area sources; model performance, accuracy and utilisation; computer models.

Mass transport of solutes, degradation of organic compounds, application of concepts to predict groundwater contaminant movement. Exposure to computer models for surface water quality, groundwater quality and air quality.

ENG(NEERI)-2-733 GIS & Remote Sensing Techniques 2 - 2 3

To educate the students on the principles and applications of Remote sensing and GIS in environmental management.
Historical Perspective, Principles of remote sensing, components of Remote Sensing, Energy source and electromagnetic radiation, Energy interaction, Spectral response pattern of earth surface features
Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR, Satellites and their sensors, Indian space programme - Research and development
Characteristics of Remote Sensing data, Photogrammetry – Satellite data analysis – Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging, RS – GIS Integration, Image processing software.
GIS Concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – GIS software
Monitoring and management of environment, Conservation of resources, Sustainable land use,

ENG(NEERI)-2-748 Water Resource Management (+Lab) 2 - 2 3

Water quality monitoring techniques for physico-chemical and microbiological parameters, water quality surveillance, rapid assessment of drinking water quality, statistical methods for determining sampling locations, health based targets, dose-response and exposure assessment, risk assessment, assessment of health impacts due to water pollution, water treatment for geogenic chemical contaminants, types, design considerations, selection/ suitability criteria, performance evaluation, operation and management options, specific considerations and their evaluation, indoor air pollution, quality assurance and quality control requirements for data collection/analysis of water quality, water safety plan for urban and rural water supplies, (grey) water reuse
Field based experiments: Soil moisture tension measurement, Capillary pressure, Soil moisture, Infiltration capacity, Soil salinity, Soil nutrients, Water quality; Map reading, impact of changes in land use through map preparation, Use of GIS and remote sensing, Computer based simulation/design, Database design, Water hammer analysis, Design of water distribution network, Applications of Kriging and Neural networks in water resources

Management of both the quality and the quantity of water in both underground (aquifers) and above ground (lakes, rivers, and streams) resources. Analysis and model very small to very large areas of the earth to predict the amount and content of water as it flows into, through, or out of a facility.. Flow and conveyance of water. design of pipelines, water supply network, drainage facilities (including bridges, dams, channels,culverts, levees, storm sewers), and canals.

ENG(NEERI)-2-751 Materials and Environmental Applications (+Lab) 2 - 2 3
Molecular environmental science ,Re-engineered materials and environmental processes, Surface Science and Catalysis including, biomaterials, biomimetic materials, Catalyst synthesis, Supported Catalysts, Biocatalysis ,Photocatalysis, Biophotocatalysis and Environmental catalysis for solar fuels, GHG Emissions and Control , carbon capture and valorisation, biomass gasification , bioenergy and biochar, Adsorption and Water treatment, Catalysts for Renewable energy;
Surface Science and Catalysis including Heterogeneous Catalysis, Catalyst synthesis, Supported Catalysts, Photocatalysis, Environmental catalysis including air pollution control.

Ion-exchange, Adsorption and Water treatment, Catalysts for Renewable energy; GHG Emissions and Control
Zeolites and zeolite-like materials (e.g., crystalline microporous aluminophosphates and their derivatives), mesoporous oxides like silica, silica-alumina etc., metal organic frameworks, pillared clays, porous carbons and related materials, Nanoporous materials their synthesis/preparation and structure, post-synthetic modification, characterization and use in various applications like adsorption/separation, catalysis etc.

ENG(NEERI)-2-752 Bioremediation (+Lab) 2 - 2 3

Concept and dynamics of ecosystem, biogeochemical cycles; Types of ecosystems, Community structure and organisation; Environmental pollution and importance of microbes, Bioremediation: Microcosms, Mesocosms, Bioaugmentation, Biostimulation
Biodiversity, Climate change research, Microbe-Plant interactions, Eco-restoration and Remediation technologies, Environmental Management, Waste management through Eco-friendly approaches, Constructed wetlands for treatment of Wastewaters, Biomolecules in remediation, Microbial diversity in different Ecosystem, Bioremediation/Phytoremediation, Carbon sequestration and Clean Development Mechanisms, Resource recovery from waste, Bio-energy, Bioproduct, Environmental Biotchnology, Green chemistry.

ENG(NEERI)-2-753 Advanced Treatment Systems 3 - - 3
Gas phase transfer: Aeration systems, Design of aeration systems.

Membrane filtration: Introduction , Process classification, Membrane configurations, Membrane operation for micro filtration, Ultra filtration and Reverse osmosis, Design of membrane systems

Microbial growth kinetics, Modelling suspended and attached growth treatment processes. Suspended growth processes for biological nitrification and denitrification, Biological nitrogen and phosphorous removal.

Advanced oxidation processes, aeration/stripping, adsorption, nanoparticles, low pressure membrane processes, and sea water desalination. Principles of mass and momentum transport, aquatic chemistry and chemical reaction engineering are applied to these unit processes

Anaerobic sludge blanket processes, Design considerations for Up flow Anaerobic Sludge Blanket process. Theory and design of Sludge treatment, sludge thickening, sludge drying, incineration, aerobic and anaerobic digestion of sludge.

Wetland and aquatic treatment systems; Types, application, Treatment kinetics and effluent variability in constructed wetlands and aquatic systems, Free water surface and subsurface constructed wetlands, Floating plants (water hyacinths and duckweed), Combination systems, Design procedures for constructed wetlands, Management of constructed wetlands and aquatic systems.

Physical separation for hazardous solid wastes , gravity flotation, dissolved air flotation, air stripping. Steam stripping, Solvent extraction. Sorption processes and chemical treatment including hydroxide, sulfide, carbonate precipitation, Solidification and stabilization, Oxidation ad reduction of solid wastes. Thermal treatment and incinerator design. Biological treatment introduction and configuration. Safe disposal methodologies. Quantitative Risk analysis and site remediation.

ENG(NEERI)-2-745 Environmental Genomics (+Lab) 2 - 2 3

History of genetic engineering, restriction, modifying and polymerase enzymes used in genetic engineering, vectors used in genetic engineering of microbes, Bacterial hosts used in cloning and expression. MolecularTechniques: Isolation of nucleic acids (DNA, RNA, e-DNA, Metagenome), PCR, optimization of PCR, gene specific and degenerate primer design, automated DNA sequencing, pyrosequencing, Principles and techniques of nucleic acid hybridization and Cot curves; Southern blotting techniques; Polymerase chain reaction; RAPD, Real Time PCR, RT- PCR

Construction of cDNA library, PCR based cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library, BAC library, Cloning methods using restriction enzymes, cloning in expression vector, cloning of PCR products.

Phylogenetics, cladistics and ontology; Phylogenetic representations – graphs, trees and cladograms; Steps in phylogenetic analysis; Methods of phylogenetic analysis – similarity and distance tables, distance matrix method; Method of calculation of distance matrix (UPGMA, WPGMA); The Neighbour Joining Method;– maximum parsimony, maximum likelihood; Phylogenetic softwares –PHYLIP

Genome maps and types; current sequencing technologies; partial sequencing; gene identification; gene prediction rules and software's; Genome databases; Annotation of genome. Genome diversity: taxonomy and significance of genomes

Methods of sequence alignment: Sequence similarity searches and alignment tools – dynamic programming algorithms; NeedIman-Wunch and Smith Waterman, Optimal global alignment and optimal local alignment; Concept ; Programmes (Dot matrix, Dot plot, Dynamic programming) ;Similarity Searches ; Sequence repeats and inversion; Database searching (BLAST and FASTA.Multiple Sequence alignment (MSA) – significance; softwares (Clustal, , ClustalW, Meme)

ENG(NEERI)-2-754 Energy & Environment 3 - - 3

Energy Crisis: Historical events, energy requirement of society in past and present situation, availability and need of conventional energy resources, major environmental problems related to the conventional energy resources, future possibilities of energy need and availability.

Non-conventional energy sources: Hydel power plant, tidal energy, biomass energy, wind energy, Hydrogen as a source of energy, energy conversion technologies, their principles,equipment and suitability in context of India. Environmental impacts of these technologies.

Solar Energy option: Sun as source of energy, direct methods of solar energy collection,process of photovoltaic energy conversion, solar energy conversion technologies and devices, their principles, working and application, environmental impacts of solar energy.

Biomass option: Concept of biomass energy utilization, types of biomass energy, conversion processes, biogas production, biomass gasification process and technologies, environmental impacts of biomass energy.

Energy Storage: Types of energy storage, devices for sensible and latent heat storage,energy storage in dry batteries, nickel-cadmium batteries, secondary heat storage,chemical storage, environmental consequences of energy storage systems.

Heat Energy recovery systems: Approaches to waste Energy Utilization, Equipment,Utilization System, objective , principles of heat transfer, Gas to Gas heat transfer, Gas to Liquid heat transfer, Recovery of waste heat in coil coating, Non-conventional liquid fuels,Heat recovery by Cogeneration.

ENG(NEERI)-2-746 Data Analysis and Parameter Estimation 2 1 - 3

Scales of measurement, data description. Probability and probability distributions,

- Sampling techniques and sampling distributions, confidence interval for population mean, Hypothesis testing, p-value, Analysis of Variance, t-distribution, f- distribution
- Discrete Fourier Transform, Estimation of spectra, Filtering, correlation and deconvolution of time sequences, ARIMA models, time series prediction
- Contingency table and Chi-square test of independence ,Linear regression models, least squares method, correlation, Spearman's rank order correlation, inferences about the parameters in the linear regression model
- Multivariate Data Analysis, Factor Analysis, Principal component analysis, Discriminant Analysis.
- Linear regression models, least squares method, inferences about the parameters in the linear regression model, generalized matrix inverse, Bayesian estimation, nonlinear parameter estimation

ENG(NEERI)-2-749 Climate Change 3 - - 3

Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation –The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.
Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC –Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change *modeling*.

Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for Different Regions– Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.

Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS)- Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.

Clean Development Mechanism –Carbon Trading- examples of future Clean Technology – Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

CSIR-NML

Mineral Processing, Metal Extraction and Resource & Waste Management

Materials & Metallurgical Engineering

"Mineral Processing, Metal Extraction and Resource & Waste Management

Semester-wise details of Course Work

FALL (SEMESTER-I): 2 compulsory and 2 Electives

Course No.	Title	L-T-P-C	Credits
ENG(NML):1-836	Tools & techniques of materials characterization*	3-0-2-4	4
ENG(NML):1-837	Thermodynamics & Kinetics of materials & Processes*	3-1-0-4	4
ENG(NML):2-840	Principles and Advances in Iron Making	3-1-0-4	4
ENG(NML):2-842	Principles and Advances in Non-ferrous Metallurgy	3-1-0- 4	4
ENG(NML):2-844	Transport Phenomena in Metallurgical Processes	3-1-0-4	4
ENG(NML):2-845	Ore enrichment by advanced processing	3-0-2-4	4
ENG(NML):2-847	Fine particle processing	3-0-2-4	4
ENG(NML): 2-848	Materials processing and manufacturing	3-0-2-4	4
ENG(NML):2-850	Materials Selection and Design	3-1-0-4	4
ENG(NML):2-854	Mechanical Behaviour of Materials	3-0-2-4	4
ENG(NML):2-863	Assessment of structural integrity	3-1-0-4	4
ENG(NML):2-861	Smart advanced materials for functional applications	3-1-0-4	4
ENG(NML):2-853	Physical Metallurgy of Steels	3-0-2-4	4
ENG(NML):2-858	Corrosion and Control	3-0-2-4	4
	Total		**16**

AUTUMN (SEMESTER-II): 4 Electives: One compulsory only for non-metallurgists

Course No.	Title	L-T-P-C	Credits
ENG(NML):1-838	Introduction to Materials#	3-1-0-4	4
ENG(NML):2-839	Advanced Mathematics and Numerical Analysis	2-2-0-4	4
ENG(NML):2-841	Principles and Advances in Steel Making	3-1-0-4	4
ENG(NML):2-843	Advances in Non-ferrous Metal Extraction	3-1-0-4	4
ENG(NML):2-846	Coal preparation technology	3-0-2-4	4
ENG(NML):2-849	Advanced metal working techniques	3-0-2-4	4
ENG(NML):2-851	Principles of Physical Metallurgy	3-1-0-4	4
ENG(NML):2-852	Microstructural Engineering	3-0-2-4	4
ENG(NML):2-855	Creep, Fatigue and Fracture mechanics	3-0-2-4	4

ENG(NML):2-856	NDE techniques for materials evaluation	3-0-2-4	4
ENG(NML):2-857	Introduction to Magnetic Materials	3-1-0-4	4
ENG(NML):3-865	Advanced mechanical property characterization	3-0-2-4	4
ENG(NML):3-864	Thin Film Technology	3-0-2-4	4
ENG(NML):3-862	Thermodynamics and kinetics of metal extraction processes	3-1-0-4	4
ENG(NML):2-860	Waste processing, recycling and environment management	3-0-2-4	4
ENG(NML):4-866	Integrated Computational Materials Engineering	3-1-0-4	4
ENG(NML):4-867	Life Cycle Assessment	2-2-0-4	4
	Total		**16**

Courses marked with * are compulsory courses for all

Course marked with **#** is compulsory only for the non-metallurgical engg background students

FALL (SEMESTER III)

Course No.	Title	L-T-P-C	Credits
	Research Methodology & Technical Communication Skills	2-1-0-2	3
	Project Proposal & Seminar		14
	Total		**16**

AUTUMN (SEMESTER IV)

Course No.	Title	Credits
	Dissertation Seminar Final Presentation & viva voce	14
	Dissertation Report	2
	Total	**16**

Coursework details

Eng(NML): 1-836: Tools and techniques of materials characterization: 3-0-2-4

Basics of Materials Characterization
Principles of optics & optical microscopy and stereology
Electron microscopy (SEM & TEM)
X-ray diffraction & crystallographic analysis, analytical electron microscopy
Advanced characterization techniques

Eng(NML): 1-837: Thermodynamics and kinetics of Materials & Processes: 3-1-0-4

Introduction to Thermodynamic laws and Kinetics;
Free Energy Equillibrium constant,
Phase equillibria,
Thermodynamics of solutions,
Absorption and adsorption,
Computational Thermodynamics.

Eng(NML): 2-838: Introduction to Materials: 3-1-0-4

Inter-atomic Interactions & Materials; Solid State of Material: Bonding in solids
Atoms in a Solid Material : Basic Concepts of Crystallography : Symmetry Operations, Unit cell, Lattices, Planes, Directions, Bravais Lattices, Point Group Symmetry, Space Group Symmetry. Concept of commensurate, incommensurate and quasiperiodic structures.
Structure of Solids: Packing of atoms in 3d-space, packing density. Defects in solids (point, line and planner defects)
Metallic Materials: Concept of phase, phase rule and phase diagram for single and binary systems. Invariant reactions in phase diagram. Concept of CCT and TTT diagram.
Phase Transformation: Nucleation and Growth, Diffusion and Diffusion Equations. Diffusion Less Transformations.
Mechanical Behaviour of Materials: Strength of a Material, Ductile Vs Brittle Material (Concept of stress, strain and related aspacts).
Basics of Polymers and Ceramics

Eng(NML): 1-839: Advanced Mathematics and Numerical Analysis: 2-2-0-4

Linear Algebra and matrix operations :
Algebra of matrices, inverse, rank, system of linear equations, symmetric, skew symmetric and orthogonal matrices. Hermitian, skew-Hermitian and unitary matrices. eigenvalues and eigenvectors, diagonalization of matrices, Cayley-Hamilton Theorem.

Vector Calculus:

Gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems (without proofs) applications.

Ordinary Differential Equations:
First order equation (linear and nonlinear), Second order linear differential equations with variable coefficients, Variation of parameters method, higher order linear differential equations with constant coefficients, Cauchy- Euler's equations, power series solutions,

Partial Differential Equations:
Separation of variables method, Laplace equation,solutions of one dimensional heat and wave equations.

Numerical Methods:
Solution of a system of linear equations by L-U decomposition, Gauss-Jordan and Gauss-Seidel Methods, Newton's interpolation formulae, Solution of a polynomial and a transcendental equation by Newton-Raphson method, numerical integration by trapezoidal rule, Simpson's rule and Gaussian quadrature, numerical solutions of first order differential equation by Euler's method and 4th order Runge-Kutta method. Introduction to finite difference (FDM) and finite element (FEM) methods

ENG(NML):2-840: Principles and Advances in Iron Making: 3-1-0- 4

Principles of Iron making,
Techniques of agglomeration (sintering and pelletization),
Raw materials characterization (RI, RDI, Swelling index, Tumbler, shatter),
BF iron making process and modeling,
Sponge iron making (coal base, gas base).
Alternative routes of iron making (COREX, HISMELT).

ENG(NML):2-841 : Principles and Advances in Steel Making: 3-1-0- 4

Principles of steel making,
Different processes of steel making,
Secondary steel making,
Ingot casting and continuous casting,
Electric processes (EAF and Induction furnace),
Alloy steel making.

ENG(NML): 2-842: Principles and Advances in Non-ferrous Metallurgy: 3-1-0- 4

Fundamental and applied aspects of pyrometallurgy, hydrometallurgy and electrometallurgy;
Principles of unit operations;
Process selection for select non-ferrous metals;
Environmental issues in non-ferrous metallurgy.

ENG(NML):2-843 : Advances in Non-ferrous Metal Extraction: 3-1-0-4

Advances in extraction of:
Base metals (Cu, Pb, Zn),
Light metals (Al, Mg Ti, Na),
Rare metals (Ga, Ge, Se, Te, W, Mo, Zr/Hf) and PGMs,
Rare earth metals;
Non-traditional resources of non-ferrous metals and metal extraction.

ENG(NML):2-844 : Transport Phenomena in Metallurgical Processes: 3-1-0-4

Fundamentals and applied aspects of transport phenomena with and without chemical reactions in metallurgical processes,
Non-isothermal kinetics of heterogeneous chemical reactions accompanied by various transport processes in metal extraction,
Principles of mathematical modeling and simulation and computational fluid dynamics and their application in metallurgical processes.

ENG(NML):2-845: Ore enrichment by advanced processing:3-0-2-4

Mineral characterization, sampling, crushing and grinding, size classification, gravity concentration, magnetic and electrostatic separation and their application in mineral industries, surface chemistry and froth flotation principles, dewatering techniques, size enlargement processes, material balance and data reconciliation.

ENG(NML):2-846: Coal preparation technology: 3-0-2-4

Coal characterization, impurities in coal, washability curve and release analysis, coarse coal cleaning, processing of coal fines, dewatering and drying practices in coal preparation, current advances in coal cleaning, coal flotation, typical flow sheets for coal preparation plants and recent developments, dry beneficiation of coal.

ENG(NML):2-847: Fine particle processing: 3-0-2-4

Fines partitioning – size and density, advanced gravity techniques – recent developments and applications in the processing of fines, selective flocculation, flotation – recent developments, plant practices and case studies in flotation, thickening, filtration, drying, agglomeration of fines

- briquetting, pelletization and sintering, case studies and recent developments in agglomeration.

ENG(NML):2-848: Materials processing and manufacturing: 3-0-2-4

Non-metallic engineering materials, Functional materials, Nano-structured materials. Hot metal processing, Casting and solidification, Rapid quenching techniques, Thermomechanical processing techniques, Welding and joining technology, Machining and surface processing, Material evaluation and quality control

ENG(NML):3-849: Advanced metal working techniques: 3-0-2-4

Metal working processes: Forging, rolling, extrusion, wire drawing; Powder forging, rolling and extrusion; Principles of advanced materials forming Introduction to deformation maps; Workability of materials; Effect of process and alloy composition; Introduction to sheet metal forming; Advanced sheet metal forming techniques; Forming limit criteria, Forming limit diagram, flow localization

ENG(NML): 2-850: Materials Selection and Design: 3-1-0-4

Brief overview of bonding, crystal structure, defect structure; Light metal alloys, Cast irons and steels, Nickel base alloys, Non-metallic engineering materials, Relationship between processing-structure-properties of various engg materials
Principles of alloy design; Tools used in designing materials- an Introduction: Processing constraints in design
Materials selection criterion type, microstructural factors, performance criteria: in service and other strategic requirements of engineering components to be designed
Economic consideration
Technologically important material properties –physical, mechanical, thermal, optical, electrical properties, materials used in important engineering sectors
Methodology for selection of materials for the component

ENG(NML): 2-851: Principles of Physical Metallurgy: 3-1-0-4

Crystal structures and defects in solid; Diffusion; Thermodynamics and kinetics of transformations; Equilibrium phase diagram; Solidification; Solid state phase transformations; Strengthening mechanism; Engineering Alloys

ENG(NML): 2-852: Microstructural Engineering: 3-0-2-4

Evolution of microstructures, microstructural instability; Recovery, recrystallisation and grain growth, Thermo-mechanical treatment and evolution of textures

Grain boundary Characterization; Heat treatment methodology; Structure-property-processing correlations.

ENG(NML): 2-853: Physical Metallurgy of Steels: 3-0-2-4

Effect of Alloying element in steel; Strengthening mechanism in steel; Hot rolling of structural steel; HSLA steel and controlled rolling; Heat treatment processes in steel; Alloy steels: DP steels, Stainless steels, Martensitic steels, Bainitic steels, TRIP/TWIP Steels; Tool steels, Hadfield steels, Maraging steels; Welding: sensitization, schafler diagram, intermetallic embrittlement, deformation induced phase transformation

ENG(NML): 2-854: Mechanical Behaviour of Materials: 3-0-2-4

Introduction to simple concepts of stress and strain tensor; Elastic stress-strain relationship; Strain energy; Mohr's circle; Plastic yielding of material; Yield point; Yield criteria; Yield locus; Flow curve, Concept of crystal geometry; Lattice defects; Modes of deformation: slip and twinning; Critical resolved shear stress for slip; Slip in a perfect lattice; Slip by dislocation movement; Stacking faults; Fundamentals of indentation hardness; Brinell, Meyer, Vicker, Rockwell hardness; Hardness conversion; Relationship between hardness and flow curve; Hardness at high temperature; Engineering stress-strain curve; True stress-strain curve; Strength and ductility measurement in a tension test; Effect of strain rate/temperature on tensile behaviour; Necking criteria; Notched bar and drop weight impact tests; Transition temperature curves; Instrumented impact testing; Introduction to fracture mechanics based design, creep and fatigue behavior of materials.

ENG(NML): 2-855: Creep, Fatigue and Fracture mechanics: 3-0-2-4

High temperature material behaviour; Time dependent mechanical behaviour; The creep curve; Stress rupture tests; Mechanism of creep deformation; Creep resistant materials/components; Structural/microstructural changes during creep; Introduction to standard test practices; Fracture mechanics as a design concept; Strain energy and stress intensity factor; Linear elastic and elasto-plastic approach to fracture mechanics; Fracture toughness K, J-integral, CTOD; R-curve; Introduction to standard test practices; Stress and strain cycles; Different approaches to fatigue design: Total life approach and defect tolerant approach; High cycle fatigue; S-N curve and FCGR; Low cycle fatigue: cyclic stress-strain curve; Coffin-Manson relationship; Strain life equation; Fatigue deformation mechanisms: PSB, cell, lybrint; Introduction to standard test practices.

ENG(NML): 2-856: NDE techniques for materials evaluation: 3-0-2-4

Basic Metallurgy for NDE: Metallurgical defects, Mechanical behaviour of materials, Fracture Mechanics, Modes of failure like fatigue, creep, corrosion, residual stress

Surface NDE Techniques: Visual Testing, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing

Acoustic Emission: Types of acoustic emissions - Basic concepts - instrumentation and signal description, background noise, inspection of pressure vessels, flaw location, inspection of composite materials.

Ultrasonic Testing: Principles of Acoustics, Generation of ultrasonic waves, Ultrasonic Inspection Methods, Testing/Evaluation/interpretation**, Recent advances in ultrasonic testing**: Ultrasonic imaging, Synthetic Aperture Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Phased Array Ultrasonic, Non-linear ultrasonic, Signal Analysis

Magnetic NDE Techniques: Magnetic Barkhausen and magnetic hysteresis techniques, applications of MBE and MHL for damage evaluation

Radiography & Thermography Techniques: Basic Principles of Radiography and Thermography, Film Radiography Radiographic Image Quality and Radiographic Techniques Special Radiographic Techniques, Applications of thermography for condition monitoring

ENG(NML):2-857: Introduction to Magnetic Materials: 3-1-0-4

Magnetic properties & Measurement: Causes of Magnetism in Materials, Basic properties like permeability, remanance, coercivity, Hysteresis and core loss, Curie temperature, domain structure, magnetostriction. Different types of exchange interactions, Effect of external physical conditions like stress and temperature on Magnetic properties.

Characterisation of soft and hard magnetic materials, domain observation, magnetic transport property, magnetic /atomic force microscopy (MFM), SQUID Magnetometer.

Advanced Magnetic Materials: Advanced materials such as rare earth alloys used in permanent magnets, soft magnetic alloys used in flux density amplification. Nanostructured and amorphous materials, magnetic wires used in sensors, multilayers magnetic materials for spintronics and in data storage applications, Ferromagnetic shape memory alloy, giant magnetoimpedance & magnetoresistance materials.

Magnetic Devices: Sensors and Actuators: Application of magnetic materials including the choice of materials for devices such as transducers, sensors and actuators. Magnetic devices used in medical, automotive, aerospace and power applications.

ENG(NML): 2-858: Corrosion and Control: 3-0-2-4

Interaction of metals' with environments, formation of electrical double layer at metals - environments interface, mixed potential theory of corrosion, Stearn-Geary and Tafel equations, stress assisted corrosion and cracking , principles involved in controlling corrosion, Development of corrosion resistant alloys and materials, protective coatings, cathodic and anodic protection, passivity, Pourbaix diagram for metals and alloys, Corrosion inhibitors.

ENG(NML):2-859: Surface degradation and engineering: 3-0-2-4

Surface structure: Atomic arrangements, kinks, ledges, surface energies, surface excess, adsorption & absorption, surface transport, Tribological Processes, corrosion,oxidation, fretting & contact fatigue, Principles and applications: metallurgical surface treatments, chemical & electrochemical treatments CVD, PVD, laser and plasma treatments, SHS and hard coatings, TBC and functionally graded coatings, Multi-layered structures, SPD & SMAT

ENG(NML): 2-860: Waste processing, recycling and environment management: 3-0-2-4

Waste generation & sources, Pollution & Mitigation in mineral & metallurgical sector, Toxicological Analysis, Management of solid, liquid/effluent & gaseous Waste, Recycling of secondary resources & waste by mineral processing/ metal extraction, Environmental standards, Values from the wastes
Characterisation of solid wastes and effluents, monitoring, treatment processes

ENG(NML): 2-861: Smart advanced materials for functional applications: 3-1-0-4

Theoretical approach to materials design & synthesis; bulk, nanostructured and multifunctional materials, materials for future technology, Advanced Magnetic materials for sensors, nanostructured ceramic materials for structural applications, damping materials, fine processing of advanced alloys, Foams, innovative processing of materials newer processes: biomimetic, SHS, severe plastic deformation.

ENG(NML): 3-862: Thermodynamics and kinetics of metal extraction processes 3-1-0-4

Review of thermodynamic fundamentals [Gibbs energy, activity, and equilibrium constant; effects of temperature and pressure on equilibrium constant/composition; Ellingham Diagram and relative stability of oxides; Gibbs phase rule; construction of stability diagrams (predominance area diagram, phase diagram, and E-pH diagram); Thermochemistry; Alternative (Henrian) standard states; dilute solutions; interaction coefficients], Principles of thermodynamics and kinetics of Pyrometallurgy, Hydrometallurgy and Electrometallurgy processes of Ferrous and non Ferrous metal extraction including, Isothermal and non-isothermal kinetics of heterogeneous reactions.

ENG(NML):3-863 Assessment of structural integrity: 3-1-0-4

Analysis of failures, Damage tolerance and fail-safety, Life assessment methodologies, Stress analysis of components, Software based life assessment

Rejuvenation and refurbishment of degraded components, Reliability analysis and risk assessment of components, Fatigue performance of structures under variable amplitude loading, Structural integrity analysis of pressure vessel and pipelines

ENG(NML)3:864: Thin Film Technology: 3-0-2-4

Thin films: definition, nucleation and growth of thin films, Application of thin films. Processing of thin films: PVD, PECVD, electron beam evaporation, RF and DC sputtering, Magnetron sputtering, laser ablation. Plasma diagnostics by Langmuir probe and OES. Influence of thickness, power, pressure, substrate temperature, and substrate target distance on the growth and microstructure of thin films. Mechanical, adhesion behavior and measurement of thin films, magnetic, optical, texture properties of thin films method of evaluations of thin films. Surface chemistry and evaluation of thin film; Advanced Patterning techniques of thin films for devices: lithography, wet chemical, electron beam, laser; Problems and issues of thin films.

ENG(NML) 3: 865: Advanced mechanical property characterization: 3-0-2-4

Multiaxial fatigue; High strain rate material testing practices; Indentation creep; Dynamic fracture toughness; Creep-fatigue interaction; Small specimen testing practices

ENG(NML)3: 866: Integrated Computational Materials Engineering: 3-1-0-4

Atomic Scale Simulations: *Density Functional Theory, Monte Carlo Simulations, Molecular Dynamics, Dislocation Statics and Dynamics,* **CALPHAD Modeling, Microstructural Simulation:** *Phase Field Modeling, Cellular Automata, Kinetic Monte Carlo,* **Finite Element and Difference Methods at Meso-Macro Scale, Polycrystal Elasticity and Plasticity Models, Integrated Materials Modeling and Simulation**

ENG(NML)3: 867: Life Cycle Assessment: 3-1-04

Life Cycle Inventory Analysis, Life Cycle Thermodynamic and Kinetic Analysis, Life Cycle Environmental Analysis, Life Cycle Cost Analysis, Life Cycle Impact assessment, Interpretation, Assessment Tools, Data Analysis, Application to some Materials, Application to Metallurgical Processes

Subject	Co-ordinators
Tools and techniques of materials characterization	Sapan K Das/ B Ravikumar
Thermodynamics and kinetics of Materials & Processes	J Pal/ M C Goswami
Introduction to Materials	A Sinha
Advanced Mathematics and Numerical Analysis	N Das/M Tarafder/SKDas
Principles and Advances in Iron Making	J.Pal/ D. Bandopadhyay
Principles and Advances in Steel Making	S. Ghorai
Principles and Advances in Non-ferrous Metallurgy	R.K.Jana / S.K.Sahu
Advances in Non-ferrous Metal Extraction	D.Mishra/ Jhumki Hait

Transport Phenomena in Metallurgical Processes	V.Kumar/ Gopi K. Mondal
Ore enrichment by advanced processing	R. K. Rath, Ratnakar Singh
Coal preparation technology	Shobhana Dey, B. Nayak
Fine particle processing	A.Das, R P Bhagat
Materials processing and manufacturing	V C Srivastava/ K L Sahoo
Advanced metal working techniques	K.L.Sahu/ D. Mondal
Materials Selection and Design	Ravi Kumar/SGC
Principles of Physical Metallurgy	Sapan K Das/G Das
Microstructural Engineering	Sapan K Das/ SGC
Physical Metallurgy of Steels	SGC/Ravi Kumar/Sapan K Das
Mechanical Behaviour of Materials	J K Sahu/ S Tarafder
Creep, Fatigue and Fracture mechanics	J K Sahu, Swaminathan
NDE techniques for materials evaluation	S Palit/ A Mitra
Introduction to Magnetic Materials	A Mitra
Corrosion and Control	T Mishra/DDNSingh
Surface degradation and engineering	Raghuvir Singh/I Chattoraj
Waste processing, recycling and environment management	K K Sahu/B D Pandey
Smart advanced materials for functional applications	L C Pathak/A Mitra
Thermodynamics and kinetics of metal extraction processes	J Pal
Assessment of structural integrity	S Shivaprasad/N Parida
Thin Film Technology	Suman K Mishra
Advanced mechanical property characterization	J K Sahu/ Shiva
Integrated Computational Materials Engineering	S Srikanth,
Whole Cycle Energy & Environment Analysis	S Srikanth, K K Sahu, Rakesh

AcSIR

CSIR-NPL

Advanced Materials Physics & Engineering

NATIONAL PHYSICAL LABORATORY (CSIR), NEW DELHI

(Advanced Materials Physics & Engineering)

Coursework for M.Tech programs

National Physical Laboratory, New Delhi

SEMESTER I

Subject	*Code*	*Credits*
Fundamentals of Electronic Materials & Semiconductor Devices	Eng(NPL)-2-871	2-1-2-4
Physics & Technology of Thin Films	Eng(NPL)-2-872	2-1-2-4
Advanced Materials Characterization Techniques	Eng(NPL)-2-873	2-1-2-4
Nanostructured materials	Eng(NPL)-2-874	2-1-2-4

SEMESTER II

Subject	*Code*	*Credits*
Research Methodology, Technical Writing & Communication Skills	Eng(NPL)-1-001	1-1-0-2
Superconducting & Magnetic Materials	Eng(NPL)-3-871	2-1-2-4
Advanced Measurement Techniques & Metrology	Eng(NPL)-3-872	2-1-2-4
Advanced Computational Physics	Eng(NPL)-3-873	2-1-2-4

SEMESTER III

Subject	*Code*	*Credits*
Quantum Optics & Advanced Solid State Optical Devices	Eng(NPL)-3-874	2-1-2-4
Engineering Materials	Eng(NPL)-2-875	2-1-2-4
Dissertation Seminar - Initial Presentation	Eng(NPL)-4-871	0-0-16-8

SEMESTER IV

Subject	*Code*	*Credits*
Dissertation Seminar - Final Presentation & viva-voce	Eng(NPL)-4-872	0-0-16-8
Dissertation Report	Eng(NPL)-4-873	0-0-32-16

Total required credits for M Tech program = 68 (38 classroom/lab teaching, 32 thesis)

Detailed Curriculum for each course

Eng (NPL)-1-001 : Research Methodology, Technical Writing and Communication Skills : 2 Credits

Faculty : Senior Scientists

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. Professional ethics, Ethics in research, Plagiarism, Case studies. Laboratory safety issues – lab, workshop, electrical, health & fire safety, safe disposal of hazardous materials.

Role and 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 (NPL)-2-871 : Fundamentals of Electronic Materials & Semiconductor Devices : 4 Credits

Faculty : Dr. Shilesh Sharma, Dr.Sanjay K. Srivastava & Dr.Pankaj Kumar

Crystal structure and reciprocal lattice, crystal binding, phonons & thermal conductivity, free electron Fermi gas, energy band diagrams and Fermi surfaces, semiconductor crystals, plasmons-polaritons-polarons, optical properties and excitons, nanocrystalline solids, phase change materials, ferroelectrics and dielectrics, basic equations of semiconductor device operation, p-n junction diode, metal-semiconductor contacts, MOSFETS, LEDs and semiconductor laser, solar cell.

Eng (NPL)-2-872 : Physics & Technology of Thin Films : 4 Credit

Faculty : Dr. K.M.K. Srivatsa, Dr. Sushil Kumar & Dr. Govind

Vacuum science & technology for thin film processing; thin films growth mechanisms, kinetic models of nucleation; thin film deposition techniques: physical vapor deposition (PVD): evaporation (resistive heating, flash, electron beam, ion beam and pulsed laser), sputtering (mechanisms and yield, dc and rf sputtering, bias sputtering, magnetron sputtering), hybrid and modified PVD, ion plating, ion beam assisted deposition, and vacuum arc deposition; chemical vapor deposition (CVD): reaction chemistry and thermodynamics of CVD, thermal CVD, atmospheric and low pressure CVD, plasma enhanced CVD (PECVD), MOCVD etc.; Chemical techniques: spray pyrolysis, electro deposition, sol-gel and Langmuir Blodgett techniques; types of thin films: metallic, dielectric & semiconducting; optical coating, thin film measurement & characterization, thickness measurements: Fizeau fringes, stylus measurement, ellipsometer etc.; ultra-high vacuum techniques and processes; electron-based techniques for examining surface and thin film processes. Surface processes in adsorption, surface processes in epitaxial growth, electronic structure and emission processes at metallic surfaces; semiconductor surfaces and interfaces; surface processes in thin film devices; in-situ characterization of epitaxial films. Defects in epitaxial films, epitaxial growth of nanostructures on silicon surfaces, graphene, III-V nitride quantum well structures for LED & Solar cells applications.

N Eng (NPL)-2-873 : Advanced Materials Characterization Techniques : 4 Credits

Faculty : Dr. G.Bhagavannarayana, Dr. Sukhbir Singh & Dr.Renu Pasricha

Fundamentals of X-rays - Bremsstrahlung and characteristic X-rays, Moseley's law, X-ray production (conventional X-ray tubes and synchrotron), X-ray absorption/K-absorption edge/filters ; X-ray crystallography, crystal systems and their corresponding Bravais lattices, space groups, reciprocal lattice, lattice planes and Miller indices, relation between lattice spacing and lattice constants, Bragg's Law, scattering of X-rays by an electron and an isolated atom and atomic structure factor, structure factor for unit cell, calculation of structure factor, X-ray scattering and systematic absences in a few crystal systems ; X-ray analysis for composition and trace elements or impurities - X-ray florescence spectroscopy, energy dispersive spectroscopy, X-ray photoelectron spectroscopy, Auger electron spectroscopy, CHN analyzer ; determination of crystal structures - X-ray Laue, single crystal X-ray and powder X-ray methods.

Characterization of crystalline perfection of single crystals & epitaxial films - crystal defects and lattice mismatch, theoretical aspects of X-ray diffraction, reflection and

scattering, high resolution X-ray Diffraction for Bragg and Laue cases, semi-kinematical theory for epitaxial layers for determination of thickness and composition, X-ray reflectometry for determination of density, thickness and interfacial roughness ; experimental aspects - monochromators, point and line focus configurations of X-ray beam, parabolic graded multilayer mirror, flow proportional and scintillation detectors, solid-state pixel detector ; high-resolution X-ray diffractometers - high-resolution X-ray diffraction curves, X-ray topography, X-ray reflectometry, grazing incidence X-ray diffractometry for in-plane diffraction, reciprocal space mapping.

Microscopy Techniques - basics of electron microscopy, electron scattering, electron atom interaction, electron emissions sources, vacuum conditions, scanning electron microscopy, different imaging modes, conventional transmission electron microscopy, high resolution transmission electron microscopy, reciprocal space, selected area electron diffraction, convergent beam electron diffraction, bright field and dark field imaging, scanning transmission electron microscopy, lattice scale imaging, interpretation of high resolution images, scanning tunneling microscopy, atomic force microscopy.

Spectroscopy techniques - Fourier transform infrared spectroscopy, Raman spectroscopy. secondary ion mass spectroscopy, electron paramagnetic resonance spectroscopy, cathodoluminescence, photoluminescence, defect structure analysis using microscopy and spectroscopy results; particle size analyzer.

Eng (NPL)-2-874 : Nanostructured Materials : 4 Credits

Faculty : Dr. A.K. Srivastava, Dr.H.K.Singh & Dr. D. Haranath

Introduction to nanomaterials, nanoparticles employing ball milling, gas condensation, laser ablation, thermal and ultrasonic decomposition, reduction methods, self-assembly, low-temperature plasma, thermal high-speed spray, sol gels, precipitation of quantum dots and other procedures; nanolayers by physical vapor deposition methods, PLD, sputtering, e-beam evaporation, MBE; Chemical Vapor Deposition (CVD); nanostructuring by nanopolishing, etching of nanostructures, lithography procedures like optical lithography, electron beam lithography, ion beam lithography, X-ray and synchrotron lithography, focused ion beams, nanoimprinting, atomic force, near-field optics. Characterization of nanomaterials for the structure, composition, defects, interfaces, grain boundaries. Generation, interpretation & application of nano-scaled defects. Physics at low dimensions, heterostructures, band engineering, quantum wires, quantum dots, effective mass approximation, quantum wells in heterostructures, square well of finite and infinite width, triangular and parabolic quantum wells, tunneling transport, potential step, T-matrices, current and conductance, resonant tunneling, tunneling in heterostructures, effects of electric and magnetic fields, density of states, conductivity and resistivity tensors, uniform magnetic field, Landau levels, S-D effect, quantum hall effect, Aharanov-Bohm effect, nanomagnetism, surface/interface magnetism, nanophotonics. Electronic devices based on nanostructures, high electron mobility transistors, resonant tunneling diode, quantum cascade laser, single electron transistor, carbon nanotube and graphene devices and spintronic devices.

Eng (NPL)-3-871 : Superconductivity and Magnetic Materials : 4 Credit

Faculty : Dr. Pushpa L. Upadhyay, Dr. Anurag Gupta & Dr. V.P.S. Awana

Introduction to superconductivity; thermodynamics of superconducting transition, two-fluid model London theory, flux-quantization, superconducting tunneling phenomena and energy gap, introduction to microscopic theory (Bardeen-Cooper-Schrieffer) of superconductivity. Type II superconductivity, mixed state and

Ginzburg-Landau theory, critical currents, flux-pinning and flux-flow. Magneto-thermal instabilities in type II superconductors. Applications of Superconductivity : materials requirement for superconducting devices, low current devices and superconducting electronics, superconducting thin films, SQUIDs and Josephson junction based devices, detectors and bolometers. High current applications, synthesis methods for wires and tape-conductors, superconducting magnets, energy storage, motors and generators. High Temperature superconductors : introduction & their unusual fundamental properties, electronic and power applications of high-temperature superconductors. Physical Properties of materials at low temperatures (specific heat, thermal conductivity, thermal expansion, electrical conductivity, magnetic and mechanical properties). Production of low temperatures, cryogenic fluids : their properties and storage, transfer devices, temperature control & measurement, production of very low temperatures, vacuum systems as applied to cryogenics.

Magnetic moments of a body, alignment of atomic magnetic moments in a solid, Ferromagnetism, Curie Point and the Exchange Integral, Magnetisation and magnetic domains, Temperature dependence of magnetization, Coercive force & hysteresis, coercivity in fine particles. Ferrimagnetism and Antiferromagnetic order, Neutron magnetic scattering Magnetism of transition metals (elements, alloys and compounds), Rare-earths and Special Oxides (Spinels, Garnets and Perovskites). Magneto-resistance, tunnel magnetoresistance, Spintronics.

Eng (NPL)-3-872: Advanced Measurement Techniques & Metrology : 4 Credits

Faculty : Dr. A.K. Bandopadhyay, Dr. K.P.Chaudhary & Dr. S.S. Rajput

Introduction of the measurement science, measurement terminology and vocabulary, basics of uncertainty in measurements, brief advance uncertainty analysis including uncorrelated and correlated measurand, accurate measurement techniques in basic and derived SI units like mass, temperature, length & dimension, pressure & vacuum, force, DC (voltage, resistance & current), AC (high voltage & current, power & energy), LF voltage & current, introduction to quantum SI, quantum definition of mass, e-mass by superconducting magnetic levitation, watt balance, I_2 stabilized He-Ne Laser, Michelson interferometer – principle theory and application, different kinds of interferometer and applications, primary laser and its importance in metrology as a standard, basics of radiometry, radiometric quantities, radiant quantities, realization of radiometry to SI, calibration for spectral irradiance responsivity, high temperature by radiation pyrometry, measurement of Boltzmann constant 'k', Josephson voltage standard, quantum hall effect, time and frequency standards, laser cooled cesium fountain, metrology instruments - standards and artifacts for key comparison, introduction to the international organizations BIPM, RMO (APMP, SIM, EORAMET etc.), OIML, ILAC, international data base – key comparison data base (KCDB), calibration measurement capabilities (CMCs), ISO/IEC 17025: 2005 quality system and conformity assessment and their use in support of technical regulations.

Eng (NPL)-3-873: Advanced Computational Physics : 4 Credits

Faculty : Dr. Ravi Mehrotra, Dr. Sumit K. Mishra & Dr. J.Pulikkotil

Introduction to computer problem solving techniques, design and anatomy of a computer program, programming in C.

Modeling of Data : least square methods, finite difference methods, numerical differentiation and integration, interpolation and extrapolation, statistical analysis

Numerical Methods : root finding, eigen systems, FFT, ordinary differential equations and boundary value problems, Runge-Kutta and predictor corrector methods, partial differential equations

Simulations : molecular dynamics and Monte Carlo methods.

Eng (NPL)-2-875 : Engineering Materials : 4 Credit

Faculty : Dr. Ajay Dhar, Dr. T.D. Senguttuvan & Mr. B. Sivaiah

Classification of engineering materials, material properties, selection of material, advanced and futuristic materials, smart materials, nanomaterials; phase diagram, equilibrium & kinetics, stable & metastable phases, nucleation and growth, metals, alloys and solid-solutions; ceramics, polymers, composites; crystal imperfections, defects, dislocations; elastic and plastic deformation, stress-strain curves, work hardening & dynamic recovery, strengthening mechanisms; solidification and crystallization, recovery, recrystallization and grain growth; creep, fatigue, fracture, oxidation and corrosion; materials processing techniques : liquid metallurgy, powder metallurgy, spray forming; secondary processing techniques : extrusion, forging, rolling; mechanical and metallurgical characterization, structure-property correlations; light weight materials, metal matrix composites, polymer matrix composites, ceramic matrix composites, carbon-based composites, nanocomposites, super-hard materials, dielectric, ferroelectric and piezoelectric materials, magnetic materials

Eng (NPL)-2-874: Quantum Optics & Advanced Solid State Optical Devices : 4 Credits

Faculty : Dr. A. Sengupta & Dr. H.C. Kandpal

Introduction to quantum mechanics - quantum theory and wave nature of matter, complementarity, wave function and its interpretation, wave packets and free particle motion, principle of superposition, wave packets and uncertainty relation, spreading of wavepackets ; wave equations and solutions - linear harmonic oscillator, eigen value and eigen functions, motion of wave packets, double oscillator ; different types of potentials - normalization of free particle wave function, potential steps, rectangular potential barrier, periodic potential, potential square well ; coherence theory - classical coherence, quantum coherence ; semiconductor photon sources and detectors - light emitting diodes, laser amplifiers and injection lasers, photodetectors, photoconductors, photodiodes and avalanche photodiodes, single photon detectors ; theory of photoelectric detection of light - differential photodetection probability, joint probability of multiple photodetection, integral detection probabilities, photoelectric detection in a fluctuating field – photoelectric bunching, photoelectric counting statistics of a fluctuating field, photoelectric current fluctuations, Hanburry Brown – Twiss effect – photon antibunching.

Introduction to time and frequency standards including historical perspectives. Basic concepts of frequency standards, macroscopic frequency sources. Basics of laser frequency standards. Characterization of noise processes – amplitude and phase noise. Statistical characterization of the noise processes. Measurement techniques of phase and frequency noise. Introduction to atomic frequency standards, primary and secondary frequency standards. Microwave atomic frequency standards such as H-maser, Rb cell standards, cesium beam standards. Sources of frequency biases and their evaluation. Physics of cold atoms – laser cooling and trapping. Optical Molasses and magneto optic traps. Polarization gradient cooling. Bose Einstein condensation. Atomic Fountain frequency standards based on cold atoms. Cesium fountain frequency standard. Evaluation of sources of frequency biases. Ion trap frequency standards. Realization of different types of traps. Microwave & optical frequency standards based on trapped ions. Synthesis and translation of optical frequencies including femto-second comb, applications of precision frequency standards.

CSIR-SERC

Engineering of Structures

Semester-wise Course Scheme

Semester-I

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
1.	ENGG(SERC) 1-906	Instrumentation & Sensors for Structural Response Measurement	3	0	2	4
2.	ENGG(SERC) 1-907	Advanced Mechanics of Materials	3	0	0	3
3.	ENGG(SERC) 1-908	Computational Methods	3	0	0	3
4.	ENGG(SERC)1-909	Advanced Engineering Mathematics	3	0	0	3
5.	ENGG(SERC) 2-906	Dynamics of Structures	3	0	0	3
		TOTAL CREDITS				16

Semester-II

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
1.	ENGG(SERC) 1-920	Research Methodology and professional practice	2	0	0	2
2.	ENGG(SERC) 2-9xx	Elective 1	3	0	0	3
3.	ENGG(SERC) 3-9xx	Elective 2	3	0	0	3
4.	ENGG(SERC)2-9xx	Elective 3	3	0	0	3
		TOTAL CREDITS				11

Electives for 2nd semester

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
		Elective 1				
1.	ENGG(SERC) 2-907	Engineering for Natural hazards	3	0	0	3
2.	ENGG(SERC) 2-908	RCC & Pre-stressed Concrete	3	0	1	3
		Elective 2				
3.	ENGG(SERC) 3-906	Health Monitoring of Structures	2	0	2	3
4.	ENGG(SERC) 3-907	Metal Structure Behaviour & Design	3	0	1	3
		Elective 3				
5.	ENGG(SERC) 2-909	Finite Element Technology-I	3	1	0	3

Semester-III

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
1.	ENGG(SERC) 2-9xx	Elective 4	3	0	0	3
2.	ENGG(SERC)3-9xx	Elective 5	3	0	1	3
2.	ENGG(SERC)3-9xx	Elective 6	3	1	0	3
3.	ENGG(SERC) 2-928	Thesis Work and Seminar				12
		TOTAL CREDITS				21

Electives for 3rd semester

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
		Elective 4				
1.	ENGG(SERC) 2-910	Plates & Shell Structures	3	0	1	3
2.	ENGG(SERC) 2-911	Bridge Engineering	3	0	1	3
		Elective 5				
3.	ENGG(SERC) 2-912	Earthquake Engineering	3	0	1	3
4.	ENGG(SERC) 2-913	Repair & Rehabilitation of Concrete Structures	3	0	1	3
		Elective 6				
5.	ENGG(SERC) 3-908	New Composite Materials in Civil Engineering Applications	3	0	1	3
6.	ENGG(SERC) 3-909	Soft Computing	3	0	1	3
7.	ENGG(SERC) 3-910	Uncertainty Handling in Engineering Decision Making	3	0	1	3
8.	ENGG(SERC) 3-911	Finite Element Technology-II	3	0	1	3
9.	ENGG(SERC) 3-912	Fatigue & Fracture of Engineering Structures	3	0	1	3

Semester-IV

Sl.	Subject Code	Subject	Hours/Week			Credits
			L	T	P	
1.	ENGG(SERC) 2-929	Dissertation Seminars				6
2.	ENGG(SERC) 2-930	Dissertation Report and Viva-Voce				14
		TOTAL CREDITS				20

The course syllabus given in the brochure indicates L-T-P-C nomenclature.

- L is the number of lecture hours per week.
- T is the number of tutorial hours per week.
- P is the number of laboratory hours per week.
- C is the number of credits for the course.

ENGG(SERC) 1-906: Instrumentation & Sensors for Structural Response Measurement

(L-T-P-C) : 3-0-2-4

Faculty : Shri K. Srinivas (CSIO), Dr. K. Ravisankar, Dr. S. Arunachalam

Introduction: Definition of Instrumentation, Why instrumentation of Structures/Structural components? concepts and Methods - Potential areas of application; measurements: Data Acquisition - Data Transmission - Data Processing - Storage of processed data - Knowledgeable information processing - Remote Structural Health Monitoring; Sensors for measurements: Electrical Resistance Strain Gages (ERSG), Vibrating Wire Strain Gages (VWSG), Fiber Optic Sensors (FOS), Temperature Sensors, Accelerometers, Displacement Transducers, Load Cells, Humidity Sensors, Crack Propagation Measuring Sensors, Corrosion Monitoring Sensors, Pressure Sensors

ENGG(SERC) 1-907 : Advanced Mechanics of Materials

(L-T-P-C) : 3-0-0-3

Faculty : Dr. Nagesh R Iyer , Dr. G.S. Palani

Concept of Stresses and Strains - Basic Concepts, Mechanical Behaviour of Materials, Stress and strain tensors, Thermal Stresses; Mechanical Properties of Engineering Materials - Stress-Strain Curve of Engineering Materials, Constitutive relations ; Solid Mechanics Approach - Principal Stresses and Strains, Axially Loaded Members, Plane stress, Plane Strain and Axisymmetric Problems, Closed and Open Coiled Helical Springs, Strain energy, Introduction to concepts of plasticity ; Bending and shear of beams - Shear Forces and Bending Moments, Bending and Shear Stresses, Elastic Deflection of Beams ; Torsion – Open and closed sections, Shear centre, warping cross-section properties, Shear flow in closed and open sections, Torsion of shafts, closed and open sections; Advanced Topics - Buckling of Compressed Members and Slenderness Ratio, Elements of Structural Vibrations, Fundamentals of Fatigue Analysis

ENGG(SERC) 1-908: Computational Methods

(L-T-P-C) : 3-0-0-3

Faculty: Dr. A. Rama Mohan Rao ,Shri. J. Rajasankar

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

ENGG(SERC) 1-909 :Advanced Engineering Mathematics

(L-T-P-C) : 3-0-0-3

Faculty:, **Dr. N. Gopalakrishnan, Shri V. Venkataraman**

Ordinary Differential Equations of the First Order , Ordinary Linear Differential Equation, Laplace Transformation, Line and Surface Integrals. Integral Theorems, Matrices and Determinants (Systems of Linear Equations), Fourier Series and Integrals, Partial Differential Equations, Sequences and Series, Taylor and Laurent Series, Special Functions. Asymptotic Expansions

ENGG(SERC) 1-920: Research Methodology &Technical Communications **(L-T-P-C) : 2-0-1-2**

Faculty Coordinator: Dr. Nagesh R Iyer

Research Methodology : Literature review ; Searching the literature; Managing references; Effective scientific writing; Effective scientific presentation; Intellectual property management ; Writing and reading Patents ; Research planning; Ethics in Science

Introduction to organisational structure; Communication Skills; Engineering Ethics and Social Responsibility; Introduction to Decision Making; Professionalism Using Standard; Social Intelligence; Decision Making in Company; Professional Judgment; Entrepreneurship and Risk Management; inter-relationships between professionalism and ethics; inter-relationships between Ethics and Social Intelligence; inter-relationships between Professional Judgment and Social Intelligence; mentoring; leadership exercises; group dynamics; conflict resolution

ENGG(SERC) 2-906: Dynamics of Structures **(L-T-P-C) : 3-0-1-3**

Course Coordinator: Dr. K. Muthumani

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

ENGG(SERC) 2-911: Bridge Engineering **(L-T-P-C) : 3-0-1-3**

Course coordinator: Dr. K. Ramanjaneyulu

Introduction - historical development, Classification and components of bridges, choice of type of the bridges, bridge aesthetics; Bridge codes – standard specifications for highway and railway bridges; Analysis and design of RC and PSC bridge decks, load distribution in slab and girder bridges, analysis and design of voided slab bridge decks, behaviour of skew bridge decks; Analysis and design of RC and PSC box-girder bridge decks; Analysis and design of steel and composite bridges; Design of bearings; Design of substructure and foundations - piers and abutments of different types, shallow and deep foundations; Modern methods of construction - Incremental launching and its impact on analysis and design, segmental construction ; Introduction to analysis and design of long span bridges: suspension and cable stayed bridges

ENGG(SERC) 2-912: Earthquake Engineering **(L-T-P-C) : 3-0-1-3**

Faculty: Dr. P. Kamatchi; Shri G.V. Rama Rao

Elements of Engineering Seismology - Causes of earthquakes - seismic waves – magnitude and intensity -characteristics of strong earthquake ground motions - Seismic Susceptibility of Indian

Subcontinent; Performance of structures under past earthquakes - Lessons learnt - Behaviour of RC, steel, Masonry and prestressed concrete structures under cyclic loading; Introduction to theory of vibrations -Flexibility of long and short period structures - concept of response spectrum; Building forms for earthquake resistance - Building Systems – Rigid Frames, Braced Frames, Shear Walls - Structural Configuration; Seismic design philosophy - Concept of Earthquake Resistant Design - Evaluation of earthquake load on structures based on IS: 1893 – response spectrum method - 3 D computer analysis of building – Importance of detailing IS 13920
Seismic Design of Non Engineered construction; Seismic evaluation and retrofitting of structures; Soil performance – Soil liquefaction – Soil structure interaction ; Seismic design provisions for bridges, dams, tanks and Industrial structures; Modern Concepts: Introduction to Passive and Active Control of Civil Engineering Structures, Base Isolation, energy dissipation devices, Adaptive systems – Case studies

ENGG(SERC) 2-908: RCC & Prestressed Concrete Structures

(L-T-P-C) : 3-0-1-3

Faculty: Dr. K. Ramanjaneyulu, Dr. B. H. Bharath Kumar , Dr. A. Rama Chandra Murthy

Yield line method of Design of Slabs: Equilibrium and virtual work methods of analysis, Rectangular slabs and triangular slabs with various edge conditions – yield line patterns, Circular slabs, Design for limit state of strength and serviceability, Orthotropically reinforced slabs; Design of Grid Floors: General features, Rigorous and approximate methods of analysis, Design of grid floors.; Design of Shear walls; Design of Deep Beams and Corbels; Design of Flat Slabs; Design of bunkers silos and chimneys; Analysis of stresses in concrete chimneys- uncracked and cracked sections- Codal provisions- Design of chimney; Importance of Detailing in Reinforced Concrete Construction.

Introduction to prestressed concrete: materials, types of prestressing systems and devices; analysis of prestressed concrete elements for flexure: concepts of stresses at transfer and service loads, ultimate strength in flexure, losses in prestress, anchorage zone stresses; philosophy of design: limit state design for flexure and shear, tendon profiles in post-tensioned and pre-tensioned members, comparative analysis of provisions of international standards; statically indeterminate structures: continuous beams and portals, secondary moments, concordancy of tendon profiles ; composite construction: longitudinal shear transfer, transverse shear, stage prestressing, creep and shrinkage effects; external prestressing; design of prestressed concrete pipes, tanks, slabs, and cylindrical shells.;construction aspects – prestressing, precast-prestressed concrete, stressing sequence; safe demolition of psc structures; methods for safe distressing of prestressed concrete structures

ENGG(SERC) 2-909: Finite Element Technology-I

(L-T-P-C) : 3-1-0-3

Faculty: Dr. Nagesh R Iyer , Dr. A. Rama Mohan Rao , Shri J. Rajasankar

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, FEM formulation from a functional, Interpolation, C_0 and C_1 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; P**late bending elements :**Plate bending theory, Mindlin and Kirchhoff element formulations, Concepts of locking, Full, reduced integration and selective reduced techniques,

ENGG(SERC) 3-910 Uncertainty Handling in Engineering Decision Making **(L-T-P-C) : 3-0-1-3**

Coordinator: Dr. K. Balaji Rao

Introduction: Basic Definitions; Examples; Different types of uncertainties; Exposure to formal frameworks for handling uncertainties; Theory & Application of Probability and Statistics: Nature and Purpose of Mathematical Statistics; Tabular and Graphical Representation of Samples; Sample Mean and Sample Variance; Random Experiments, Outcomes, Events; Probability; Permutations and Combinations; Random Variables. Discrete and Continuous Distributions; Mean and Variance of a Distribution; Binomial, Poisson, and Hypergeometric Distributions; Normal Distribution; Distributions of Several Random Variables; Random Sampling. Random Numbers; Estimation of Parameters; Confidence Intervals; Testing of Hypotheses, Decisions; Quality Control; Acceptance Sampling; Goodness of Fit. X^2-Test; Nonparametric Tests; Pairs of Measurements. Statistical Tables; Application of stochastic processes for engineering decision making : Basic definition of stochastic process; Some commonly used stochastic processes; Learning models for engineering decision making – learning in both stationary and non-stationary environment; Application of fuzzy sets in engineering decision making :Basic definition of fuzzy sets; Some commonly used fuzzy sets; Use of fuzzy stochastic models for engineering decision making; Handling of uncertainties using possibility and plausibility theories ; Introduction to application of game-theoretic approaches for engineering designs

ENGG(SERC) 3-909: Soft Computing **(L-T-P-C) : 3-1-0-3**

Coordinator: Dr. A. Rama Mohan Rao

Introduction: Introduction of Soft-computing tools, Fuzzy Logic, concepts meta-heuristics, Evolutionary algorithms, Neural Networks and Probabilistic Reasoning; Artificial Neural Networks (ANN): Different Architectures, Back-propagation Algorithm, Hybrid Learning Rule, Supervised Learning- Perceptrons, Adaline, Back-propagation Multilayer Perceptrons, Radial Basis function Networks. Unsupervised Learning – Competitive Learning Network, Kohonen Self-Organizing Networks, Hebbian Learning, 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; Fuzzy Set Theory: Basic Definition and terminology, Basic Concepts of Fuzzy Logic, Set Theoretic Operators, Membership functions- formulation and parameterization. Fuzzy Union, Intersection, and Complement. Fuzzy Rules and Fuzzy Reasoning. Fuzzy Inference Systems-Mamdani and Sugeno Fuzzy models. Fuzzy Associative Memories;Evolutionary Algorithms: Basics of evolutionary Algorithms, Design issues in evolutionary Algorithm, evolutionary computing; Applications with Soft Computing Tools: Case studies with ANN, fuzzy and Hybrid approaches. Multi-objective optimization and decision making.

ENGG(SERC) 2-910:Plate and Shell Structures **(L-T-P-C) : 3-0-1-3**

Faculty: Dr. K. Balji Rao; Dr. K. Ramanjaneyulu

Thin plates, Kirchhoff theory - strain displacement relations, stresses and stress resultants, constitutive equations, equilibrium equations, boundary conditions, Analysis of rectangular and circular plates with different boundary conditions and loadings ; thick plates-Reissner-Mindlin-Naghadi type theories; orthotropic plates, plates on elastic foundation; Buckling of plates; Membrane and bending theory for analysis of singly curved and doubly curved shells – long and short cylindrical shells, single and multi barrel shells, Beam-arch approximation for long cylindrical shells; Analysis of surfaces of revolution – domes, cylindrical, conical and hyperboloid of revolution subjected to different types of loadings; Analysis and shells of translation - elliptic paraboloids, hyperbolic paraboloids; Analysis of folded plates;

ENGG(SERC) 3-907: Metal Structure Behaviour and Design **(L-T-P-C) : 3-0-1-3**

Faculty: Dr. S.J. Mohan, Dr. G.S. Palani , Dr. N. Prasada Rao

Frame design review -Second Order Effects and Moment Magnification; Stability and Leaning Columns; Philosophies of design - ASD vs. LRFD and Structural Reliability; Failure Criteria; Brittle Fracture/Ductile Yielding; Von Mises Yield Criteria; Fatigue - Stress Life, Strain Life, Fracture Mechanics; Variable Amplitude Loading and Miner's Rule; Fatigue Design Requirements; Bending behavior - General Flexural Theory; Unsymmetrical Bending Biaxial Bending Tapered Members; Torsion - Pure Torsion Shear Flow Shear; Center of Open Thin-Walled Sections Uniform Torsion; Torsion of Structural Shapes; Non-uniform Torsion; Combined Torsion and Bending Torsion of Closed Thin-Walled Sections, Single Cell and Multi-Cell; Lateral torsional buckling - Elastic and Inelastic; Columns, plates, and compression members - Local Buckling of Plate Elements; Design Criteria; Torsional Compression Buckling; Design of Aluminum Structures: Introduction, Stress-Strain Relationship, Permissible Stresses, Tension and Compression Members, Laced and Battened Columns, Beams; Beam-column and frame behavior –Approximate 2^{nd} order effects; Elastic and Inelastic Behavior; CONNECTIONS - Review of Bolt and Weld Strength; Riveted and Bolted Connections Design Aids Example; Microwave Towers – Introduction, structural configuration, function, analysis and design. Transmission Towers – Introduction, structural configuration, bracing systems, analysis and design, codal provision for design of tower and foundation; Tubular Structures - Tubular Trusses, joint details, tubular scaffoldings, codal provisions; Cold Form light gauge section- Type of cross section, Stiffened, multiple stiffened and un-stiffened element, flat- width ratio, effective design width, Design of light gauge compression, tension and flexural members

ENGG(SERC) 3-906: Health Monitoring of Structures **(L-T-P-C) : 3-0-1-3**

Faculty: Dr. K. Ravisankar, Dr. N. Gopalakrishnan

Static Field Testing: Requirements for carrying out static field testing -Types of static tests - Behavioural/ Diagnostic tests - Proof tests - Simulation and loading methods - Static response measurement; Dynamic Field Testing: Stress history data - Dynamic load allowance tests - Ambient vibration tests - Forced Vibration Method - Dynamic response methods; Periodic and Continuous Monitoring; Long term performance monitoring using integrated sensing methods - Monitoring through ambient vibration - Monitoring through testing under service load conditions - Assessment of crack growth - Loss of prestress; Data Acquisition Systems; Static data acquisition systems - Dynamic data acquisition systems - Hardware for Remote data acquisition systems; Remote Structural Health Monitoring: Importance and Advantages - Methodology - RF/PSTN/GSM/Satellite Communications - Networking of sensors - Data compression technique; Case Studies

ENGG(SERC) 2-913: Repair & Rehabilitation of Concrete Structures **(L-T-P-C) : 3-0-1-3**

Faculty: Dr. B.H. Bharthkumar, Shri T.S. Krishnamurthy

General: Introduction , cause of deterioration of concrete structures, Diagnostic methods & analysis, preliminary investigations ,experimental investigations using NDT, load testing, corrosion mapping, core drilling method; Serviceability and Durability: Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors; Maintenance and Repair Strategies: Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance Preventive measures on various aspects. Assessment procedure for evaluating a damaged structure; Causes of deterioration – testing techniques; Techniques for Repair: Corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection. Strengthening of structural elements with various methods; Case Studies: Structures affected due to corrosion related failure

ENGG(SERC) 3-908: New Composite Materials in Civil Engineering Applications

(L-T-P-C) : 3-0-1-3

Faculty: Shri T.S. Krishnamurthy, Dr. (Mrs) J. Annie Peter

Concrete Composite: Fresh concrete and hardened concrete – Mix Design – Use of Admixtures Mechanical and Durablity properties; Fibre Reinforced Concrete (FRC):Types of Fibres – Factors affecting strength and stiffness of fibre concrete– Production of FRC – Tests on FRC – Applications of FRC; ferrocement-production and application; High Performance Concrete (HPC): Definition – Constituent materials – Production methods – Advantages of HPC – Applications of HPC; self compacting concrete; definition – constituent material – mix proportion – production methods – various tests on SCC – applications of SCC; Polymer Concrete Composite: Classification of Polymer concrete – Methods of Production – Advantages of Polymer Concrete – Applications of Polymer Concrete; FRP composites: Constituent materials – Method of Productions – Properties and Production method – Applications

ENGG(SERC) 2-907: Engineering for Natural Hazards

(L-T-P-C) : 3-0-1-3

Faculty: Dr. S. Arunachalam, Dr. S. Selvirajan, Dr. K. Balaji Rao

Hazard Characteristics: Seismology and ground motion characteristics; Extreme wind Characteristics; Hazard Estimation: Deterministic methods; Stochastic methods; Probabilistic and deterministic seismic hazard analysis; Risk analysis of cyclonic wind speed; Post Disaster Damage Surveys: Earthquake Disaster; Cyclone Disaster; Materials and Methodology of Constructions; Vulnerability Analysis: Damage Probability Matrix approach; Fragility Analysis approach; Risk analysis life quality index Approach; Guidelines for Disaster Resistant Structures: Earthquake Disaster; Cyclone Disaster

ENGG(SERC) 2-909: Finite Element Technology-II

(L-T-P-C) : 3-0-1-3

Faculty: Dr. Nagesh R Iyer, Dr. A. Rama Mohan Rao, Shri J. Rajasankar, Dr. G.S. Palani

Lagrangian formulation, Constitutive relations, Solution techniques;
Formulations related to nonlinear dynamic analysis
Error estimation and adaptive refinement techniques – *A posteriori* error estimation for static, vibration and dynamic problems; h-, p-, r- and mixed adaptive refinements.
Introduction to mesh free methods

ENGG(SERC) 3-912: Fatigue & Fracture of Engineering Structures

(L-T-P-C) : 3-0-1-3

Faculty: Dr. G. Raghava, Dr. G.S. Palani, Shri P. Gandhi, Shri T.S. Krishnamurthy

Introduction to Fatigue: Loads – Cyclic loads – High cycle fatigue – Low cycle fatigue; Stress-life Approach: *S-N* curve – Size effect – Loading effect – Surface … plating, thermal, and mechanical – Temperature – Environment; Strain-life Approach: Introduction – Material behaviour – Monotonic stress-strain behaviour, Basic definition – True and engineering stress-strain relationship, Cyclic stress-strain behaviour, Cyclic strain hardening and softening, Cyclic stress-strain curve determination, Stress-strain power law relation; Fatigue Life Calculation: – Prediction of fatigue life using S-N and Miner's approach – General,calculation of equivalent stress range, stresses to be considered, S-N curves and joint classifications, – Prediction of crack propagation using da/dN vs ΔK curves – General, Constant amplitude loading, variable amplitude loading, geometric functions and crack growth integrals– General, load calculation, stress calculation, … probability of failure – Design formats – General, allowable stresses, allowable cumulative damage ratio, comments on the design formats; Fracture:…Stress distribution at discontinuities – Stress concentration factors – Cracks …

Linear Elastic Fracture Mechanics (LEFM):Stress intensity factor – *monotonic and cyclic loads* - Fracture toughness – Energy theories – *J*-integral; Crack Growth Studies: Fatigue crack growth … Constant amplitude loading – Variable amplitude loading – Crack growth models –Remaining life prediction – Residual strength evaluation – Plastic collapse condition, Yield condition, Remaining life approach … Fracture of Concrete Structures: Fracture mechanics approach for concrete – Limitations – Nonlinear fracture models with tension softening – Fracture energy – size effect – Remaining life prediction – Residual strength evaluation.

List of Faculty (CSIR-SERC)

S. No	Name	Designation	Field of Specialisation
1	Dr. Nagesh R Iyer	Director	Computational Mechanics, Fatigue, fracture Expertise and damage mechanics, Performance evaluation of Structures
3	Dr. K. Muthumani	Chief scientist	Structural Dynamics and Earthquake Engineering
4	Dr. K Ravisankar	Chief scientist	Experimental Mechanics and Health Monitoring.
5	Dr. S. Arunachalam	Chief scientist	Wind Engineering, cyclone disaster mitigation.
6	Mr. T.S. Krishnamoorty	Chief scientist	RCC Design, Repair & Rehabilitation of structures.
7	Dr. A Rama Mohan Rao	Sr. Principal Scientist	Computational Methods, Combinatorial optimization.
8	Dr. N. Gopalakrishnan	Sr. Principal Scientist	Structural Dynamics and Earthquake Engineering.
9	Dr. G. Raghava	Sr. Principal Scientist	Fatigue and Fracture
10	Dr.(Ms.) Jolly Annie Peter	Chief scientist	Concrete composites, special concrete
11	Dr. Kanchi Balaji Rao	Sr. Principal Scientist	Risk and Reliability
12	Dr. K. Ramanjaneyulu	Scientist-F	Bridge Engineering , RCC design
13	Dr. K. Rama Raju	Sr. Principal Scientist	Vibration control of structures
14	Dr. S.J. Mohan	Chief scientist	Steel Structures, tower testing
15	Dr. P. Sivakumar	Sr. Principal Scientist	Steel structures, structural optimization
16	Dr.(Ms.) Selvi Rajan	Chief scientist	Wind Engineering, cyclone disaster mitigation
17	Dr. P. K. Umesha	Sr. Principal Scientist	Steel structures, structural optimization
18	Mr. J.Rajasankar	Sr. Principal Scientist	Computational Mechanics, Damage Mechanics
19	Dr. G. S Palani.	Sr. Principal Scientist	Computational Mechanics, Fatigue and Fracture
20	Mr. Palla Gandhi	Sr. Principal Scientist	Fatigue and Fracture.
21	Mr. N.G. Bhagavan	Sr. Principal Scientist	Structural Engineering
23	Mr. C. Jayabal	Sr. Principal Scientist	Mechanical Engineering
24	Mr. P Srinivasan	Principal Scientist	Non Destructive testing, Concrete structures
25	Mr. J.Prabakar	Principal Scientist	Non Destructive testing, Concrete structures
26	Mr. S. Parivallal	Principal Scientist	Structural testing and health monitoring
27	Dr. B.H. Bharatkumar	Principal Scientist	RCC design, fracture of concrete structures
28	Dr. P.Harikrishna	Principal Scientist	Wind Engineering, CFD

30	Mr. K. Sathish Kumar	Sr. Principal Scientist	Structural Dynamics and Earthquake Engineering.
31	Mrs. N. Anandavalli	Sr. Scientist	Blast &impact design of structures
32	Mr. A Rama Chandra Murthy	Sr. Scientist	RCC design, Fracture mechanics
33	Mr. K. Kesavan	Sr. Scientist	Structural testing and health monitoring
34	Mr. G. Ramesh Babu G	Principal Scientist	Wind Engineering, CFD
35	Mr. Rajendra Pitambar Rokade	Sr. Scientist	Steel structures , tower testing
36	Ms. R. Sreekala	Sr. Scientist	Structural Dynamics and Earthquake Engineering.
37	Mr. Sangoju Bhaskar	Sr. Scientist	Structural Mechanics
38	Mr. Voggu Srinivas	Sr. Scientist	Bridge Engineering , RCC design
39	Mr. Amar Prakash	Scientist	Blast &impact design of structures
40	Ms. Ambily P.S.	Scientist	Concrete composites, special concrete
41	Mr. R. Bala Gopal	Scientist	Steel Structures, tower testing
42	Mr.S.R.Balasubramanian	Scientist	Masonary structures
43	Ms. S. Chitra Ganapathi	Scientist	Wind Engineering, CFD
44	Mr. C. Kumarasekar	Scientist	Tower testing
45	Mr. G V. Rama Rao	Scientist	Structural Dynamics and Earthquake Engineering.
46	Ms. Prabha Prahalathan	Scientist	Steel structures
47	Ms. Smitha Gopinath	Scientist	Computational mechanics, RCC structures
48	Mr. Sivasubramanian K	Scientist	Non Destructive testing, Concrete structures
49	Mr. V. Marimuthu	Scientist	Steel structures
50	Dr. M B Anoop	Sr. Scientist	Risk and Reliability, fuzzy theory
51	Dr.(Ms.) P. Kamatchi	Sr. Scientist	Earthquake design of structures
52	Mr. Prasad Rao Napa	Sr. Scientist	Steel structures , tower testing
53	Dr. Saptarshi Sasmal	Sr. Scientist	Bridge Engineering , RCC design
54	Dr. Cinitha Appu	Scientist	Earthquake design of structures
55	Dr.N. Lakshmikandhan	Scientist	Retrofitting & rehabilitation of structures
56	Dr. R. Manisekar	Scientist	Retrofitting & rehabilitation of structures
57	Dr. S. Vishnuvardhan	Scientist	Fatigue and fracture
58	Mr. A. Abraham	Sr. Scientist	Wind Engineering
59	Mr. DM. Pukazhendhi	Sr. Scientist	Fatigue and Fracture.
60	Shri K. Srinivas	**SIC (CSIR-CSIO)**	Sensor technologies, Non-conventional energy
61	Shri Venkataraman	Sr. Principal Scientist(CEERI)	

CSIR-SERC

Renewable Energy

Semester-wise Course Details

Semester - I

Course code	Title	Credits
RE 501	Renewable Energy Sources for a Sustainable Future	2
RE 502	Harnessing the Power of Sun: Science and Technology of Solar Photovoltaics	4
RE 503	Energy Storage and Conversion: Science and Technology	4
RE 504	Mathematical Methods for Renewable Energy Engineering	2
RE 505	"View from the TOP" seminar series I	1

Semester - II

Course code	Title	Credits
RE 506	Design and Engineering for Sustainability	2
RE 507	"View from the TOP" seminar series II	1
Electives (Two electives)		
RE 601	Solar Photovoltaics: Power Electronics, Power Transmission and Energy Monitoring	4
RE 602	Advanced course on Lithium-Ion Batteries	4
RE 603	Design of Structures for Renewable Energy	4
RE 604	Bio-Energy: The Plants work & Let us Reap	4

Summer Internship Project

Course code	Title	Credits
RE 605	CSIR 800 Field work and Project proposals (3 Months)	4

Semester - III

Course code	Title	Credits
RE 606	Self-study course on Advanced topics in Renewable Energy	4
RE 607	3-4 weeks Industrial training (Report and Presentation)	1
RE 608	4 week Solar Energy Workshop for High-school students (Organizing and Mentoring)	2
RE 609	Effective Presentation Skills and Dissertation Writing	1
RE 610	Dissertation (Seminars and report)	8

Semester - IV

Course code	Title	Credits
RE 611	Dissertation seminars	6
RE 612	Dissertation report and Viva-Voice	18

M.Tech Program Credits Summary:

Total credits: 64 (32 Course work (excluding CSIR 800 Project) + 32 (Dissertation seminars and report))

PhD Program Credits Summary:

Total course credits: 36 (32 M. Tech course work (excluding CSIR 800 Project) + Additional Elective 4 credits (Any one extra elective from RE 601-604)))

Participating Faculty: 20^{+}

RE 501: 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

RE 502: 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, Dye-sensitized 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)

RE 503: 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.
- 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.

Re 504: Mathematical Methods for Renewable Energy Engineering Course Coordinator: Dr. Madan Kumar Lakshmanan	(1-1-0-2) 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

RE 505: "View from the TOP" Seminar Series I Course Coordinator: Dr. Bala Pesala	(1-0-0-1) 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

RE 506: 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

RE 507: "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

RE 601: Solar Photovoltaics: Power Electronics, Power Transmission and Energy Monitoring Course Coordinator: Dr. Bala Pesala Faculty: Shri. K. Srinivas, Shri. Suriya Prakash, Shri. G. S. Aiyappan	(3-0-2-4) 4 Credits

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

RE 602: Advanced course on Lithium-Ion Batteries Faculty: Dr. K. Ramesha , Dr. A. S. Prakash	(3-0-2-4) 4 Credits

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).

RE 603: Design of Structures For Renewable Energy Course Coordinator: Dr. Saptarshi Sasmal Faculty : Dr. J. Rajasankar, Dr. P. Harikrishna, Shri. G. Ramesh Babu	(2-1-2-4) 4 Credits

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

RE 604: Bio Energy: The Plants Work & Let Us Reap Course Coordinator: Dr. Carmalin Sophia Faculty: Dr. Rima Biswas	(3-0-2-4) 4 Credits

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

RE 609: 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.

Renewable Energy Program Coordinators:

Dr. Bala Pesala (CSIR-CEERI Chennai), Dr. Saptarshi Sasmal (CSIR-SERC)

Faculty List and Details

Faculty Name	Designation	Area of Expertise
Dr. Bala Pesala	Senior Scientist, CSIR-CEERI	Solar energy, Photonics
Dr. Saptarshi Sasmal	Senior Scientist, CSIR-SERC	Bridge engineering, Mechanics of materials and structures, Strengthening of structures
Dr. J. Rajasankar	Senior Principal Scientist, CSIR-SERC	Computational Mechanics, Damage Mechanics
Dr. P. Harikrishna	Principal Scientist, CSIR-SERC	Wind engineering, CFD
Shri. G. Ramesh Babu	Principal Scientist, CSIR-SERC	Wind engineering
Dr. Carmalin Sophia	Scientist, CSIR-NEERI	Environmental chemistry
Dr. Rima Biswas	Scientist, CSIR-NEERI	Microbiology
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Shri. Rahul Verma	Chief Scientist, CSIR-CEERI	Power electronics, Renewable energy
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Dr. Santosh kumar Bhat	Scientist, CSIR-CECRI	Polymers/electrochemistry
Dr. K. Ramesha	Senior Scientist, CSIR-CECRI	Materials for energy storage
Dr. P. Sridhar	Senior Principal scientist, CSIR-CECRI	Electrochemistry & chemical engineering
Dr. A. Manokaran	Scientist, CSIR-CECRI	Chemical engineering
Dr. A.K. Sahu	Scientist, CSIR-CECRI	Electrochemistry/materials science
Dr. S. Pitchumani	Chief Scientist, CSIR-CECRI	Polymers/electrochemistry
Shri. K. Srinivas	Senior Principal Scientist, CSIR-CSIO	Electronic Instrumentation, Photonics
Shri. G. S. Aiyappan	Scientist, CSIR-CSIO	Electronic Instrumentation
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