COURSE SYLLABI

FOR

Ph.D. PROGRAM

Course Syllabi (Ph.D.)
Department of Chemistry

Course Code: SCL604
Course Title: ROLE OF ORGANOMETALLIC COMPOUNDS IN ORGANIC SYNTHESIS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Organopalladium Chemistry: reactions involving organopalladium intermediates – palladium-catalyzed nucleophilic substitution and alkylation, Heck reaction, palladium-catalyzed cross coupling, and carbonylation reactions.

Organolithium reagents: Use of Organolithium in organic synthesis: *n*-BuLi, *s*-BuLi, *t*-BuLi, Lithium di-isopropylamide (LDA) mediated reactions.

Organocupper regents: Use of Organo Cupper in organic synthesis: Gilman's reagent, applications. **Organoboron chemistry:**carboranes, hydroboration, reaction of organoboranes, unsaturated hydrocarbon synthesis, allylboranes, allylenolates.

Organosilicon chemistry: Comparison of Silicon and carbon compounds, silicon Baeyer-Villiger rearrangement, nucleophilic substitution at silicon, silyl ethers and alkyl silanes as protecting groups, aryl and vinyl silanes, migration of silicon from carbon to oxygen.

Organophosphorous chemistry: phosphorus ylides- Wittig reaction and its modifications; phosphine oxides and its applications.

Organosulfur chemistry: sulfur-stabilization of anions and cations, sulfurylides, sulfoxides and sulfones, PyrolyticSyn elimination.]

Organotitanium Chemistry: Synthesis, stability and chemoselective Grignard &Aldol reaction, Michael additions, olefin formation, substitution reactions,Tebbe's reagent.

Organotin Chemistry: Synthetic reactions mediated by transmetallation of organotins: tri-*n*-butyl tin hydride reactions.

Organomagnesium Reagent: Use of Grignard reagents in organic synthesis

Text Books:

1. Modern Methods in Organic Synthesis: W. Carruthers and I. Coldham, Cambridge University Press.
2. Advanced Organic Chemistry: Jerry March, Wiley.

Reference Books:

1. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structures, M. B. Smith and Jerry March, Wiley.
2. Organic Chemistry: R. T. Morrison & R. N. Boyd, Pearson Publisher.

Course Code: SCL605
Course Title: MOLECULAR SPECTROSCOPY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Introduction to Molecular Spectroscopy: The Born-Oppenhimer approximation, transition probability, oscillator strength, the integrated absorption coefficient.

Absorption spectroscopy (UV-Vis): Various electronic transitions (185 to 800 nm), Lambert-Beer's Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, diens, conjugated polyenes. Fieser-Woodward rules for conjugated diens and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Luminescence spectroscopy.

Infrared Spectroscopy: Introduction. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the bond positions and intensities, Fermi resonance. Characteristic vibrational frequencies of various functional groups. Effect of hydrogen bonding, solvent effect on IR of gaseous and solids materials. Vibrational energies of diatomic molecules, zero point energy, force constant and bond strength. Anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy: P,Q,R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Simple applications.

Nuclear Magnetic Resonance: Nuclear Spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing the chemical shift, Deshielding, spin-spin interaction, factors influencing coupling constant (*J*). Coupling – vicinal and geminal coupling, long-range coupling, spin decoupling, Spin systems (AX2, A2B2 & A2X2 and AMX, ABX, & ABC etc.), NMR studies of nuclei other than proton: ^{13}C, ^{19}F and ^{31}P. NOE, simplification of complex spectra by the use of Shift reagent and field strength. 2-D NMR, Introduction, NOESY, COSY, HETCOR.

Mass Spectroscopy: Introduction, ion production, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, example of Mass fragmentation of organic compounds with respect to their structure determination.

Text Books:

1. Silverstein R. M., Webster F. X., Kiemle, D. J., Bryce D. L., Spectroscopic Identification of Organic Compounds, Wiley 8th Edition.
2. Kemp W. Organic Spectroscopy, Palgrave.

Reference Books:

1. Abraham, R.J. and P. Loftus, Proton and Carbon-13 NMR Spectroscopy, Heyden & Son Ltd.
2. Modern NMR Techniques for Chemistry Research, Derome A. E., Pergamon, 1987.
3. Introduction to Molecular Spectroscopy, Barrow G. M., McGraw-Hill, 1962
4. Spectroscopic Methods in Organic Chemistry: Williams D., & Fleming I., Tata McGraw-Hill Edition.

Course Code: SCL606
Course Title: SYNTHETIC ORGANIC CHEMISTRY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Disconnection approach: Synthons and synthetic equivalents, definitions, guidelines, functional group interconversions, use of acetylenes and aliphatic nitrocompounds in organic synthesis; two-group C-C disconnections – Diels-Alder reaction, 1,3- & 1,5- difunctional compounds (Michael addition & Robinson annulation); chemoselectivity, regioselectivity, stereoselectivity, reversal of polarity (umpolung), cyclisation reactions, and amine synthesis. Protection and de-protection of common functional groups (hydroxy, carbonyl, carboxylic and amino groups).

Synthetic strategies: – linear and convergent synthesis, Multicomponent reactions, One-pot reactions, Domino, Cascade and tandem reactions; Directed ortho-metallation, Pd, Rh, Ru, Ir catalyzed C-H activation reactions and functionalizations, Metathesis reactions, Asymmetric organocatalysis; enzymatic catalysis.

Name Reactions & their applications in Organic/Natural product Synthesis: Aza-Cope and Aza-Wittig reactions, Baylis-Hillman reaction, BINAL and BINAP assisted reactions, Click reaction, RCM olefin metathesis and Grubb's catalyst, Julia-Lythgoe olefination, Mukayama aldol reaction, Mitsunobu reaction, McMurray reaction, Peterson's stereoselective olefination, Suzuki Coupling, Heck Coupling, Hiyama coupling, Stille coupling, Buchwald-Hartwig coupling, Fukuyama Coupling, Sonagashira Coupling, Henry reaction, Sharpless epoxidation, Shi epoxidation, Jaconsen epoxidation, Jacobsen-Katsuki epoxidation, Apple reaction, Bamford-Stevens Reaction, Shapiro

Reaction, Petasis reaction, CBS reduction, Luche reduction, Nef reaction, Pinacol rearrangement, Reformatsky reaction, Sonogashira Coupling, Simmons-Smith reaction, Horner-Wadsworth-Emmons reaction, Yamaguchi esterification, Barton decarboxylation, Corey-Chaykovsky reaction, Corey-Fuchs reaction, Click chemistry.

Text Books:

1. Catalytic Asymmetric Synthesis, I. Ojima(ed.), 3rd Edition, Wiley, 2010.
2. Berkessel A. and Gröger H., "Asymmetric Organocatalysis" Wiley, 2005.
3. Organic chemistry–Clayden,J; Greeves, N; Warren, S; and Wothers, P. 2nd Edition Oxford Press, 2012.

Reference Books:

1. Lin G.-Q., Li Y.-M. and Chan A.S.C., "Principles and Applications of Asymmetric Synthesis", Wiley, 2001.
2. Ojima I.(Editor), "Catalytic Asymmetric Synthesis", 2nd Ed., Wiley, 2004.
3. Comprehensive Asymmetric Catalysis, I-III, E. N. Jacobsen, A. Pfaltzand H. Yamamoto, Springer, 1999.
4. Principles of Asymmetric Synthesis – R. E. Gawley and J. Aub, Pergamon, 1996.
5. Asymmetric Catalysis in Organic Synthesis, R. Noyori, Wiley, 1994.
6. Asymmetric Synthesis with Chemical and Biological Methods, D. Enders and K. E. Jaeger, Wiley-VCH, 2007
7. Asymmetric Synthesis, vol 1-5, H. S. Mosher and J. D. Morrison (ed.), Academic Press
8. Smith M. B: Principles of Organic Synthesis

Course Code: SCL607
Course Title: PHOTOCHEMISTRY & PERICYCLIC REACTIONS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Pericyclic Reactions:
Electrocyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene 1,3 butadiene, 1,3,5, hexatriene and allyl system, classification of pericyclic reactions, Woodward- Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic Reactions:- Conrotatory and Disrotatory motion, 4n, 4n+2 and allyl systems.
Cycloadditions:– Antarafacial and Suprafacial addition, 4n and 4n+2 systems, Diels-Alder reactions, 2+2 addition of ketenes, 1,3, dipolarcycloadditions, Hauser annulation, synthesis of different natural products using Hauser annulations.
Sigmatropic Rearrangements:-suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3, and 5,5 sigmatropic rearrangements. Ene reaction, retro ene reactions, cheletropic reactions, and group transfer reactions, detailed treatment of Claisen, Cope, Sommelet-Hauser rearrangement and different related problems.
Photochemistry: Photochemical reactions; determination of reaction mechanism; photochemistry of alkenes, carbonyl compounds, enones and aromatic compounds. Photochemical processes, Jablonski Diagram, Reactions of Anilides. Photochemical Rearrangements, Lumiketone rearrangement, Norrish-Type A and Type B reactions, Di-pi-methane rearrangement, Oxa-di-pi-methane rearrangement, Barton reaction, reaction of hypohalites, Photo-Fries rearrangement. Photo induced electron transfer (PET) reactions. Photoredox catalysis. Photochemistry of vision. Photosynthesis and different problems.

Text Books:

1. Photochemistry of organic compounds, Klan P, Wirz J. 1st Edition, Wiley, 2009,
2. Frontier Orbitals and Organic Chemical Reactions, Flemming, I. Wiley, London, 1976.

Reference Books:

1. Organic reactions and orbital symmetry, Gilchrist T. L. and Storr R. C., 2nd Edition, Cambridge University Press, 1979.
2. Conservation of orbital symmetry: Woodward R. B. and Hoffmann R., Chemie V, Weinheim, 3rd printing 1971.
3. Smith M. B., Principles of Organic Synthesis
4. Organic photochemistry, Chapman, O.L. Vol. I & II, Marcel Decker, 1969.
5. Orbital Symmetry: A problem solving approach, Lehr R. E. and Marchand A. P., Academic press, 1972.
6. Finar I. L., Organic Chemistry Vol. II and I

Course Code: SCL608
Course Title: HETEROCYCLIC CHEMISTRY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Heterocycles: Systematic nomenclature of heterocyclic compounds (Hantzsch-Widman, Replacement & Fusion methods), Biological importance of heterocyclic compounds.
Five-membered heterocycles with one heteroatom:
Chemical structures of furan, pyrrole and thiophene, and degree of aromaticity. General syntheses methods for 5-member rings. Paal-Knorr, Feist-Benary, Hantzsch and Knorr syntheses. Electrophilic substitution in this kind of rings, reactants employed and orientation of the substituent on the ring.
Benzoderivatives of five-membered heterocycles with one heteroatom: Preparation of indole and carbazole derivatives. Fisher, Bischler, Madelung and Reissert syntheses. Preparation and reactivity of benzofurans (coumarins), benzothiophenes, dibenzofurans and dibenzothiophenes.
Pyridines, quinolines and isoquinoles: Influence of the imine group on the reactivity of the pyridine ring. Nucleophilic and electrophilic substitutions on pyridine, quinolines and isoquinolines. Comparison of reactivity with benzene and naphthalene. Preparation of pyridine salts and pyridine *N*-oxides and synthetic applications. Skraup, Friedlander, Pfintzinger Bischler-Napieralski and Pictet syntheses. [10-Lectures].
Heterocycles with 5 or 6 members and two or three heteroatoms: Syntheses and reactivity of Oxazoles, thiazoles, oxadiazoles, thiadiazoles, benzothiazoles, benzothiadiazoles, triazole, benzotriazole, pyrimidines, pyrazines, quinoxalines, triazines, etc.

Text Books:

1. Heterocyclic chemistry, 3rd Edition, T. L. Gilchrist, Pearson Education India, 2007.
2. Heterocyclic chemistry, M. Sainsbury, Wiley, 2002.

Reference Books:

1. Heterocyclic Chemistry, J. A. Joule and K. Mills, Wiley-Blackwell, 2010
2. An introduction to the chemistry of heterocyclic compounds, third edition, R. M. Acheson, John Wiley and Sons, New York, 1976

Course Code: SCL641
Course Title: ORGANOMETALLIC CHEMISTRY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Bonding models in sigma and pi-complexes. 18- electron formalism and isolobal principle. Basic organometallic reactions.18 electron rule, metal carbonyl, carbonylate anions, nitrosyles, hydrides, dioxygen&dinitrogen compounds.Metal alkyl, carbenes, alkene, alkynes &allyl complexes. Metal arene complexes and metellocenes.
Reactions of organometallic complexes and Fluxional Behaviour: Substitution, oxidative addition, reductive elimination, insertion and deinsertion. Fluxional molecules, Fluxionality and dynamic equilibria in compounds such as n^2-olefin, n^3-allyl and dienyl complexes.

Homogeneous catalysis: Stochiometric reactions for catalysis homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reactions, activation of C-H bond. organometaliic catalysis, Terminology in catalysis: Turnover, turnover number (TON), Turnover frequency (TOF), Hydrogenation, Hydroformylation, Monsanto process, Wacker process.

Book Suggested:

1. Cotton, F. A. and Wilkinson, G.W., Advanced inorganic chemistry, John Wiley, 1988.
2. Crabtree, R.H., Organometallic chemistry of the transition metals, John Wiley, 1993, 2nd Ed.
3. Yamamoto, A., Organotransition metal chemistry "Fundamental concepts and application, John Wiley, 1986.

Course Code: SCL642
Course Title: SUPRAMOLECULAR CHEMISTRY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Supramolecular chemistry: Introduction/definition of Supramolecular chemistry (interactions beyond the molecule, modern description of non-covalent interactions 'energy/thermodynamic considerations, media dependence, cooperativity). Binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, H-bonding, cation-π, anion-π, π - π, van der Waals interactions and their role in molecule recognition.

Tools of supramolecular chemistry : Quantifying inter/intramolecular interactions (Spectroscopic and analytical methods used in supramolecular chemistry including modern/advanced NMR techniques; titration studies and determination of stoichiometry/binding constants in 1:1, 2:1, 1:2 systems; kinetic versus thermodynamic stability, kinetics/affinity regimes and choice of methods).

Building blocks of supramolecular chemistry : Synthesis and structure of crown ethers, lariat ethers, podands, cryptands, spherands, calixarenes, cyclodextrins, cucurbiturils, cyclophanes, cryptophanes, carcerands and hemicarcerands, pillerarenes, host-guest interactions, pre-organization and complimentarity, lock and key analogy, Binding of cationic, anionic, ion pair and neutral guest molecules, and their important applications in catalysis, making smart material etc.

Self-assembly molecules: Design, synthesis and properties of the molecules, self-assembling by H-bonding, π-π interactions, metal-ligand and other weak interactions, Amphiphilic molecules and their aggregation, metallomacrocycles, catenanes, rotaxanes, helicates, knots Supramolecular Organic Frameowrks (SOFs).

Molecular Machines: Functional supramolecular assemblies. Molecular devices: molecular electronic devices, molecular wires, molecular rectifiers, molecular switches, molecular logic gates.

Crystal engineering: Concept, Role of H-bonding, Halogen Bonding and other weak interactions.

Relevance of supramolecular chemistry to mimic biological systems: cyclodextrins as enzyme mimics, ion channel mimics, supramolecular catalysis etc.

Examples of recent developments in supramolecular chemistry from current literature.

Text Books:

1. Lehn, J.-M., Supramolecular Chemistry-Concepts and Perspectives (Wiley-VCH, 1995).
2. Beer, P. D., Gale, P. A., Smith, D. K.; Supramolecular Chemistry (Oxford University Press, 1999).
3. Steed, J. W. and Atwood, J. L.; Supramolecular Chemistry (Wiley, 2000).
4. Steed, J. W. and Atwood, J. L, 'Supramolecular Chemistry', 2nd Edition; ISBN: 978-1-118-68150-3.
5. Review articles, research papers, templates will be made available.

Course Code: SCL643
Course Title: ADVANCED INORGANIC CHEMISTRY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Inorganic reaction mechanism: Energy profile of a reaction, understanding reaction mechanism-linear free energy relationship, effect of leaving group, non-leaving group, entering group, steric hindrance and acceleration; solvent exchange reaction, derivation of some important rate laws, kinetically indistinguishable schemes, classification of ligand substitution reaction mechanism-associative, dissociative, interchange, etc., Eigen mechanism, proton ambiguity, internal conjugate base formation.

Cluster compounds

Introduction, clusters in elemental states, cluster classification, skeletal electron (Elm) counting, higher boron hydrides structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT), zintl ions, chevrel compounds, infinite metal chains, cluster surface analogy.

Complexes in aqueous solutions

Metal ligand stability constant and its controlling factors, different tools of study (pH-potentiometric, polarographic, spectrophotomectric, volumetric) and methods of measuring stability constants of complexes, stability of mixed ligand complexes and calculations, determination of composition (Jobs, mole ratio and slope ratio methods), evaluation of thermodynamic parameters.

Metal–Organic Framework (MOF) Materials:

Designing, synthesis and geometric principles, challenges, structure–property relationships, chiral MOFs, selective catalysis, Water photolysis using MOF, CH_4/H_2 storage, selective CO_2 capture and selective gas adsorption.

Books recommended:

1. Huheey, J.E., Inorganic Chemistry: Principal of Structure & Reactivity, 4thEd., Publisher - Addisom-Wesley.
2. Greenwood, N.N. and Earnshaw, A.,Chemistry of the Elements., Publisher - Butterworth-Heinemann Ltd (Elsevier).
3. Miessler, G.Y. and Tarr, D.A. Inorganic Chemistry (IIIrd Edition).
4. Satyaprakash, Tuli, Basu and Madan, Advanced Inorganic Chemistry, Vol.-I.
5. Malik, W.U., Tuli, G.D. & Madan, R.D. Selected Topics in Inorganic Chemistry.
6. Shriver, D. and Atkins, P., Inorganic Chemistry., W. H. Freeman, 2009.
7. Chhatwal, G. R., Mehra, H. Advanced Inorganic Chemistry Vol. I & Vol. II.
8. Editor: Leonard R. MacGillivrayMetal-Organic Frameworks: Design and Application., Publisher - Wiley.
9. Editor: Schröder, Martin, Functional Metal-Organic Frameworks: Gas Storage, Separation and Catalysis, Springer.

Course Syllabi (Ph.D.)
Department of Computer Science and Engineering

Course Code: CSL601
Course Title: WIRELESS SENSOR NETWORK
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents: Components of a wireless sensor node, Motivation for a Network of Wireless Sensor Nodes, Classification of sensor networks, Characteristics of wireless sensor networks, Challenges of wireless sensor networks, Comparison between wireless sensor networks and wireless mesh networks, Limitations in wireless sensor networks, Design challenges, Hardware architecture Node Architecture: The Sensing Subsystem, the Processor Subsystem, Communication Interfaces, Prototypes. Operating Systems: Functional Aspects, Nonfunctional Aspects, Prototypes, Evaluation. Case Study Applications: Structural Health Monitoring, Traffic Control, Health Care, Pipeline Monitoring, Precision Agriculture, Active Volcano, Underground Mining, IoT. Basic Architectural Framework: Physical Layer, Basic Components, Source Encoding, Channel Encoding, Modulation Medium Access Control: Wireless MAC Protocols, Characteristics of MAC Protocols in Sensor Networks, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols Network Layer: Routing Metrics, Flooding and Gossiping, Data-Centric Routing, Proactive Routing, On-Demand Routing, Hierarchical Routing, Location-Based Routing, QoS-Based Routing Protocols Node and Network Management: Power Management, Local Power Management aspects, Dynamic Power Management, Conceptual Architecture. Time Synchronization: Clocks and the Synchronization Problem, Time Synchronization in Wireless Sensor Networks, Basics of Time Synchronization, Time Synchronization Protocols Localization: Ranging Techniques, Range-Based Localization, Range-Free Localization, Event Driven Localization. Security: Fundamentals of Network Security, Challenges of Security in Wireless Sensor Networks , Security Attacks in Sensor Networks, Protocols and Mechanisms for Security, IEEE 802.15.4 and Zig-Bee Security. Introduction to IoT, Sensing, Actuation, Basics of IoT Networking, Communication Protocols in IoT, Machine-to-Machine Communications, Interoperability in IoT.
Text Books:
1. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", Wiley 2010
2. Mohammad S. Obaidat, Sudip Misra, "Principles of Wireless Sensor Networks", Cambridge, 2014

Reference Books:
1. Ian F. Akyildiz, Mehmet Can Vuran , "Wireless Sensor Networks", Wiley 2010
2. C S Raghavendra, K M Sivalingam, Taieb Znati, "Wireless Sensor Networks", Springer, 2010
3. C. Sivarm murthy & B.S. Manoj, "Adhoc Wireless Networks", PHI-2004.
4. FEI HU., XIAOJUN CAO, "Wireless Sensor Networks", CRC Press, 2013.
5. Feng ZHAO, Leonidas GUIBAS, " Wireless Sensor Networks", ELSEVIER , 2004.

Course Code: CSL 602
Course Title: BIOMETRIC RECOGNITION
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents: Introduction: Biometric Systems, Verification, Identification, Design Cycle, Applications, Security and Privacy Concerns. Fingerprint Recognition: Friction Ridge Pattern, Fingerprint Acquisition, Feature Extraction, Matching, Palmprint recognition and its applications. Face Recognition: Image Acquisition, Face Detection, Feature Extraction and Matching, Advanced Topics. Iris Recognition: Design, Iris Segmentation, Normalization, Encoding and Matching.
Additional Biometrics: Ear, Gait, Hand Geometry, Soft Biometrics. Multibiometrics: Introduction, Sources of Multiple Evidence, Acquisition and Processing Architecture, Fusion Levels. Security of Biometric Systems: Adversary Attacks, User Interface, Biometric Processing and Template Database Attacks.
Text Books:
1. A. K. Jain, A. A. Ross and K. Nandakumar, Introduction to Biometrics, Springer International, 2011
Reference Books:
1. A. K. Jain, P. Flynn and A. A. Ross, Handbook of Biometrics, Springer International, 2007
2. R. M. Bolle, S. Pankanti, N. K. Ratha, A. W. Senior, J. H. Connell, Guide to Biometrics, Springer 2009

Course Syllabi (Ph.D.)
Department of Electrical Engineering

Course Code: EEL601
Course Title: COMPUTATIONAL TECHNIQUES IN ENGINEERING
Structure (L-T-P): 3-0-0-3
Prerequisite: EEL208, EEL316, EEL210
Contents:

Least Squares problem, Canonical forms obtained via orthogonal transformations. Numerical methods and conditioning, State estimation and kalman filter, Generalized least squares (GLS) and instrumental variable (IV) method; Persistently exciting input signal; Likelihood functions and maximum likelihood estimation (MLE); Singular value decomposition (SVD); Introduction to system identification: identification based on differential equations, Laplace transforms, Frequency responses, Difference equations. Signals and system concepts, Stationarity, Auto-correlation, Cross-correlation, Power spectra. Random and deterministic signal. Markov's Inequality, Variance and moments of a random variable, Chebyshev's Inequality, A randomized algorithm for computing the median. System modeling and simulation. Controller design: PID, Sliding mode controller

Text Book:

1. Jain, Iyengar and Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.

Reference Books:

1. Athanasios Papoulis S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, 4th Edition, TMH publication.
2. Miller and Freund, Probability and Statistics for Engineers, Pearson, 2005.
3. Henry Stark and John W. Woods Probability And Random Processes With Application To Signal Processing, 3/E, Pearson Publication.

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Course Code: EEL602
Course Title: INTELLIGENCE TECHNIQUES APPLICATION TO POWER SYSTEM
Structure (L-T-P): 3-0-0-3
Prerequisite: EEL305
Contents:

Introduction to artificial intelligence. Use of expert systems in power system, Monitoring operation and control. Expert systems in fault diagnosis. Applications of Neural network based power system estimators and controllers. Fuzzy logic based controllers. Alarm analysis and decision making processes. Applications of imaging and pattern recognition for system identification and control. Database management and computer graphics aided decision making processes. Artificial intelligence method of crisis control and restoration processes. Application of GA, PSO and NSGA in power system problem solution.

Text Book:

1. D P Kothari , J S Dhillon,Power system Optimisation, Prentice-Hall of India Pvt.Ltd, 2004.
2. S A Soman, S A Khaparde and Shubha Pandit,Computational Methods for Large Sparse Power Systems Analysis: An Object Oriented Approach, Springer, 2001.

Reference Books:

1. M L Crow, Computational Methods for electric power system, CRC Press, 2015.
2. Kevin Warwick , Arthur Ekwue ,Raj Aggarwal, Artificial Intelligence techniques in power systems, Institution of Engineering and Technology, 1997

Course Syllabi (Ph.D.)
Department of Humanities and Social Sciences

Course Code: HML601
Course Title: COMMUNICATION SKILLS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Basics of Communication: Introduction to communication, Definition, Its process and types, Barriers to Communication, communication for specific purpose, technical communication, Communication in research and academic environment. VAT: Video Apperception Test. **Four Skills of Language:** Listening, Speaking, Reading, Writing; Methods and Comprehension, Note-Making and Narrating, etc.

Written and Spoken Skills: Methods and Comprehension , Writing English as a Process including Planning, Drafting, Reviewing, Revising and Criticizing, Correct Usage and Expression, Writing Srategies, mechanics and stylistics of written, Speaking for specific purpose, Dynamics of Kinesics, Haptics in Oral Communication, Preparation of power point presentation, Oral Presentation, Poster Presentation, Group Discussion, Symposium etc.

Soft Skill: Personality Development, Time and Stress Management in Professional Context, Video Speeches by personalities of different sections of knowledge.

Research Writing: Articles for publication (journals), writing abstract, dissertation, qualities of research writing and documentation.

Text Books:

1. Hartley, Peter and Clive G. Bruckmann, *Business Communication*, London & New York: Routledge, 2002
2. Butterfield, Jeff. *Soft Skills for Everyone*. Cengage Learning Ind. Pvt. Ltd., 2017.

Reference Books:

1. Kumar, Sanjay and Pushp Lata, *Communication Skills*, 2nd Edition, New Delhi: OUP, 2015.
2. Murphy, Herta and Herbert William Hildebrandt, and Jane Thomas. *Effective Business Communication*, 7th edition, McGraw Hill Education, 2017.

Course Code: HML602
Course Code: RESEARCH METHODOLOGY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Unit-I: Goals, Categories and Research Formulation: Motivation and objectives, Research methods, Methodology, Categories of research: Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual and Empirical, Defining and formulating the research problem, Literature review, Web as a source.

Unit-II: Research Plan, Methods and Data Collection: Selection of Research Topic, Developing a research plan: Experimentation, Determining experimental and sample designs, Basic Principles, important concepts relating to research plan, Observation and Facts. Collection and Methods of data collection, Sampling Methods, Data Processing and Analytical strategies, Testing of hypothesis.

Unit-III: Reporting and Thesis writing: Outlining and Writing Draft: Working outline, Thesis Statement, First Outline, Structure, Mechanics of Writing Research Paper and Thesis: Spelling, Punctuation, Italics, Capitalization, Names of Person, Number, Titles of Work in research writing, Use of Quotation, Use of Foreign Names and words, language and style of research writing, Abbreviation.

Unit-IV: **Format of Research Paper:** Margins, Spacing, Text Formatting, Heading and Title, Page Numbers, Tables and Illustrations, Paper Printing, Corrections and Insertions, Binding, Electronic Submission preparation, types and layouts of scientific reports, research papers & theses, Significance and language of synopses, Illustrations and tables, Bibliography, Referencing and Footnotes, index. Presentations: Poster, Oral presentation, PPT, Submission process of articles in the journals, conferences, different article formats, review process of the journals, communication with editorial board, Justification of research work, presentation of graphical abstract, supporting information, etc., learning how to respond to referee queries, proof reading, etc. Journal indexing: SCI, SCI (E), Scopus, web of science, Google scholar etc.

Unit-V: Application of Research, Ethics, IPR and Scholarly publishing: Social/Environmental impacts, Ethical issues, Copy right, Royalty, Intellectual property rights and patent law, Trade Related aspects of Intellectual Property Rights, Plagiarism, Citation and acknowledgement, Reproducibility and accountability, referee process, citation and acknowledgement.

Text Books:

1. Gibaldi, Joseph. *MLA Handbook*, 7th ed. The Modern Language Association of America, 2016.
2. *MLA Style Manual and Guide to Scholarly Publishing*. 3rd large print ed. Modern Language Association of America, 2008.
3. Allison, Brian and Phil Race. *Student's Guide to Preparing Dissertations and These*.1st edition, Routledge, 2015.
4. Garg, B.L., Renu Kavdia el at. *An Introduction to Research Methodology*, RBSA Publishers, 2002.
5. Babbie, Earl. The Basics of Social Research. 7th Edition, CENGAGE Learning Custom Publishing, 2015.
6. Smart, Walter K. *Handbook of Effective Writing*. Forgotten Books, 2017.
7. The Chicago Manual of Style, 17 ed. UCP, 2017.

Reference Books:

1. Booth, Wayne C. Gregory G. Colomb, et al. *The Craft of Research: Chicago Guide to Writing, Editing and Publishing* 4th edition, U P of Chicago Press, 2016.
2. Miller and Miller, *Mathematical Statistics*, 7th edition, Singapore, Pearson publication, 2013.
3. Kothari, C.R., *Research Methodology: Methods and Techniques*, 2nd Edition, New Age International Publishers, 2004.
4. Kumar, Ranjit, *Research Methodology- A Step-by-Step Guide for Beginners*, 2nd edition, Singapore, Pearson Education, 2005.
5. Dawson, Catherine. *Practical Research Methods*, New Delhi, UBS Publishers Distributors, 2002.
6. Goode, W.J. and Hatt P. K., *Methods in Social research*, 1st edition, McGraw Hill publication New York, 1952.

Course Code: HML603
Course Title: THEORY OF LITERATURE
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Introduction: The Nature and function of Literature, Literature Theory Scope: Criticism, History, General

Comparative and National Literature Extrinsic Approach to Study Literature: Biographical and Psychological Approach Literature, Society and Ideas

Intrinsic approach to study literature: Image, metaphor, symbol, myth, Euphony, Rhythm, Meter, Style and Stylistics,

Interpretation and the Analysis of the Literary Work of Art

The Ordering and Establishing of Evidence

Literary Genres

Value and Evaluation

Literary Terms and Movements

Text Book:

1. Cuddon, J.A. and M.A.R. Habib. *The Penguin Dictionary of Literary Terms and Literary Theory*. 5th ed. Penguin, 2015. Print.
2. Wellek, Rene and Austin Warren. *Theory of Literature*. New York: Harcourt Brace and Co., 2017. Print.

Reference Books:

1. Daiches, David. *Critical Approaches to Literature*. Kessinger Publishing, 2010.
2. Abrams, M.H. *The Mirror and the Lamp: Romantic Theory and the Critical Tradition*, OUP. Print.

3. Abrams, M.H. and Geoffrey Galt Harpham. *A Glossary of Literary Terms.* Cengage Learning India Pvt Ltd., 11th ed., 2015.
4. Eagleton, Terry. *How to Read Literature*. London: Yale U P, 2013. Print.
5. Eagleton, Terry. *Literary Theory: An Introduction*. Wiley India Pvt. Ltd. 2008. Print.

Course Code: HML604
Course Title: INTRODUCTION TO CULTURAL AND ECO-CRITICAL STUDIES
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Cultural Theories: Scope, Aim and Methods, Key Concepts Theories: Poststructuralism and Deconstruction, Marxism. Postmodernism, Feminism and Post-feminism, Queer Theory, Postcolonial Theory, Techno-culture, Posthumanism

Location: Modernity and Postmodernity, Globalization, Nation-State, New Social Movements, Fundamentalism

Perspectives: Folklore, Gender, Media, Film, Science, Environment in Cultural Frame

Ecocritism: Nature and Humanity, Nature and Culture, Literary Studies and Environmental Crises

Positions: Deep Ecology, Eco-feminism, Social Ecology and Eco-Marxism

Apocalypse: Environmental Apocalypticism, Apocalypse and Millennium

Dwelling and Animals

Future: Environmental Humanities

1. Textual Study of Essays"Some Principles of Ecocriticism." William Howarth
2. "Revaluing Nature: Towards an Ecological Criticism." Glen A. Love

Text Books:

1. Baker, Chris and Emma A. Jane. *Theory and Practice of Cultural Studies*: *Theory and Practice*. Los Angeles: Sage, 2016. Print.
2. Nayar, Paramod K. *An Introduction to Cultural Studies*. Second Edition. Viva Books. 2017
3. Garrard, Greg. *Ecocriticism*. Special Indian Edition. Routledge. 2013

Reference Books:

1. Glotfelty, Cheryll and Harold Fromm. *The Ecocriticism Reader: Landmarks in Literary Ecology*. University of Georgia Press
2. Nayar, Pramod K. *From Text to Theory: A Handbook of Literary and Cultural Theory*. New Delhi: Viva Books, 2017. Print.
3. Heffernan, Nick and David A. Wragg, eds. *Culture, Environment and Ecopolitics*. Cambridge Scholars Publishing, 2011. Print.
4. During, Simon, ed. The Cultural Studies Reader. 3rd Edition. London: Routledge, 2007. Print.

Course Code: HML-605
Course Title: LITERATURE OF THE INDIAN DIASPORA
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

In this course, the students will study the poetry, drama and fiction of some recent and contemporary Indian diasporic poets/playwrights and writers like Meena Alexander, Rana Bose, Rohinton Mistry, Amitav Ghosh, Jhumpa Lahiri and Kiran Desai and etc. The following issues and concerns will be examined in relation to their fiction:

Unit-I: Theoretical Concept of Diaspora

Issues of diaspora, location, history and memory in literature; the relationship between literary texts and their historical, political and cultural contexts; the relationship between geography and form, between location and representation; the experiences of dislocation, relocation, acculturation and marginalization as explored and addressed in the literary works;

Unit-II Concept of 'Home' in Diaspora

Writers' configurations of the notions of home, cultural identity and belonging, etc.; Changing concepts of home and cultural identity across generations of diasporic writers; the local and the transnational; plurality of home/homelands

Textual interpretation / analysis: V S Naipaul: *A House for Mr Biswas*; Salman Rushdie: *Imaginary Homelands*

Unit-III: Mapping the Indian Diaspora: Global and Regional Perspectives

Migration and Remittances: The Impact of Countries of Origin; Role of Migration and Diaspora in Sustainable Development Goals (SDGs); Role of Regional Diasporas in Development Process: A Case Study of Gujarati/Bhojpuri and Keralite Diaspora; Theories and Methodology of Migration and Diaspora: A Critical Understanding; Migration and Diaspora Policies

Textual interpretation / analysis: M G Vassanji: *The Gunny Sack* (1989); Amitav Ghosh, *Sea of Poppies* (2008)

Unit-IV: Post-colonial Migration

Postcolonial migrancy; dynamics of migration; creating new relations between cultures of origin and adoption; nature and scale of Sub continental migration; the effects of decolonization, transnationalism, and the LPG; the earlier nineteenth century model of diaspora; the colonial history of indenture; economic and professional advancement in the West.

Textual interpretation / analysis: Jhumpa Lahiri, *The Namesake* (2003); Kiran Desai, *The Inheritance of Loss* (2006)

Text Books:

1. Desai, Kiran. The Inheritance of Loss (2006). New Delhi: Penguin, 2014. Print.
2. Ghosh, Amitav. Sea of Poppies (2008). New Delhi: Penguin, 2011. Print.
3. Lahiri , Jhumpa. The Namesake (2003).Noida: Harpercollins, 2007. Print.
4. Naipaul, V S. A House for Mr Biswas (1961). New Delhi: Picador, 2001. Print.
5. Rushdie, Salman. "Imaginary Homelands". Imaginary Homelands: Essays and Criticism 1981–1991 (1992). New Delhi: Penguin Books, 1992. Print.
6. Vassanji, M G. The Gunny Sack (1989). New Delhi: Penguin India, 2009. Print.

Reference Books:

1. Brah, Avtar. Cartographies of Diaspora: Contesting Identities. London & New York: Routledge, 1996. Print.
2. Cohen, Robin. Global Diasporas: An Introduction. (Second Edition). London and New York: Routledge, 2008. Print.
3. Crane, Ralph J. & Radhika Mohanram, eds. Shifting Continents/Colliding Cultures: Diaspora Writing of the Indian Subcontinent. Amsterdam & Atlanta GA: Rodopi, 2000. Print.
4. Jain, Jasbir, ed. Writers of the Indian Diaspora. 1998. Jaipur: Rawat, 2011. Print.
5. ---. The Diaspora Writes Home: Subcontinental Narratives. Jaipur: Rawat, 2015. Print.
6. Mishra, Vijay. Literature of the Indian Diaspora: Theorizing the Diasporic Imaginary. London and New York: Routledge, 2007. Print.
7. Paranjape, Makarand, ed. In Diaspora. New Delhi: Indialog, 2001. Print.

Course Code: HML-606
Course Title: NEW LITERATURES IN ENGLISH
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Unit-I- Poetry:

A. D. Hope: "Australia"; Judith Wright: "Failure of Communion"; A. K. Ramanujan: "Death and the Good Citizen": Nissim Ezekiel: "Poet, Lover, Birdwatcher"; Jayanta Mahapatra: "Hunger"; Uma Parmeswaran: "Trishanku";

Derek Walcott: "A Far Cry from Africa"; Wole Soyinka: "Dedication";

Unit-II- Prose/Non-fiction:

M. G. Vassanji: "Am I a Canadian Writer"; George Lamming: "In the Castle of My Skin"; Ngugi wa Thiong'o: "Decolonising the Mind"; Frantz Fanon: "The Fact of Blackness"; Chinua Achebe: "An Image of Africa: Racism in Conrad's "Heart of Darkness"

Unit-III- Drama:

Wole Soyinka: *Dance of the Forest*; Derek Walcott: *Drums and Colours*;

Unit-IV- Fiction:

Chinua Achebe: *Things Fall Apart*; V. S. Naipaul: *The Mimic Man*; Kunzang Choden: *The Circle of Karma*; Manjushree Thapa: *The Tutor of India*;

Text Books:

1. Goodman, Burton. *Literature for English Advanced Two*. New Delhi: McGraw-Hill Higher Education, 2004. Print.
2. Hornstein, Herlands, Lillian, G. D. Percy, *et al*. *The Reader's Companion to World Literature*. USA: Penguin, 2002. Print.
3. Naik, M K. *A History of Indian English Literature*. New Delhi: Sahitya Akademi, 13th imprint, 2009. Print.
4. Lazarus, Neil. *Resistance in Postcolonial African Fiction*. New Haven: Yale University Press, 1990. Print.

Reference Books:

1. Gikandi, Simon: *Routledge Encyclopaedia of African Literature*. New York & London: Routledge, 2003. Print.
2. Kumar, Bishun, Neha Arora. *Major Voices in New Literatures in English*. New Delhi: Atlantic, 2015. Print.
3. Naik, M K, Shyamala A Narayan. *Indian English Literature: 1980-2000*. New Delhi: Pencraft International, 13th imprint, 2009. Print.
4. Zepetnek, Steven Totosy De and Tutun Mukherjee. Companion to Comparative Literature, World Literatures, and Comparative Cultural Studies. New Delhi: CUP, 2012. Print.
5. Wilde, William H. The Oxford Companion to Australian Literature. Australlia: OUP, 1994. Print.

Course Syllabi (Ph.D.)
Department of Mathematics

Course Code: SCL 615
Course Title: BIOLOGICAL MATHEMATICAL MODELLING
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Continuous Growth Models, Insect Outbreak Model: Spruce Budworm, Delay Models, Linear Analysis of Delay Population Models Harvesting a Single Natural population.Population Model with Age Structure, Fishery Management model. Predator- Prey models, Lotka-Volterra Systems, Competition Models.
Principle of competitive exclusion, Mutualism or Symbiosis, Stability analysis of Predator- Prey Models, Stability – Analysis of Competition Models.
Epidemic models and the dynamics of infectious diseases: Simple epidemic models, SIS, SIR and SIRS Epidemic Models.Modelling Venereal Diseases, Multi- group Model for Gonorrhea, AIDS: Modelling the Transmission Dynamics of HIVIntroduction to Compartment models, Discrete and continuous transfers, Discrete Population Models for a single species. Discrete logistic model, Discrete delay models for single species, solution by eigen value analysis.
Text Books:
1. Murray, J.D., Mathematical Biology: I. An Introduction, 3rdEdition, Springer 2002.
2. Cullen, M.R., Linear Models in Biology, Ellis Horwood Ltd, Jhon Wiley & Sons, 1985.

Reference Books:
1. Kapur, J.N., Mathematical Models in Biology and Medicines, 2008.
2. Rubinow, S.I., Introduction to Mathematical Biology, John Wiley & Sons. 1975.

Course Code: SCL 616
Course Title: ADVANCED NUMERICAL ANALYSIS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Computations of Eigen Values of a Matrix: Power method for dominant, sub-dominant and smallest eigen-values, Method of inflation, Jacobi, Givens and Householder methods for symmetric matrices, LR and QR methods.
Initial Value Problems: Multistep methods, their error analysis and stability analysis, interpolation Theory: Polynomial Interpolation theory, Newton divided differences, Hermite interpolation, Piecewise polynomial interpolation, Trigonometric interpolation, Results on Interpolation error.
Finite Difference: Review of finite difference operators, finite difference methods.
Elliptic PDE: Five point formulae for Laplacian, replacement for Dirichlet and Neumann's boundary conditions, curved boundaries, solution on a rectangular domain, block tri-diagonal form and its solution using method of Hockney, condition of convergence.
Parabolic PDE: Concept of compatibility, convergence and stability, Explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations with error analysis.
Hyperbolic PDE: Solution of hyperbolic equations using FD, and Method of characteristics ,Limitations and Error analysis.
Basic definitions and types of Integral Equations, Galerkin Method for Singular Integral Equations, General Numerical Procedure for Cauchy Singular Integral Equation, Numerical Solution of Hypersingular Integral Equation using Simple Polynomial Expansion.
Text Books
1. Jain, M.K., Iyengar S.R.K and Jain, R. K., Numerical Methods for Scientific and Engineering Computation, New Age International Publisher, 2006.
2. Mandal B.N., Chakrabarti, A.N., Applied Singular Integral Equation, CRC Press, Taylor & Francis, 2011.

Reference Books
1. Atkinson, K.E., An Introduction to Numerical Analysis, Wiley, 2nd Ed., 2014.
2. Smith, G. D., Numerical Solutions to Partial Differential Equations, Oxford University Press, 3rd Ed., 1986.
3. Morton K. W.,Mayers, D. F., Numerical Solution of Partial Differential Equations, Cambridge University Press, 2nd Edn., 2005.
4. Dzhuraev, A., Methods of Singular Integral Equation, Longman Scientific & Technical, John Wiley & Sons, 1992.

Course Code: SCL 617
Course Title: MATHEMATICAL THEORY OF FINITE ELEMENT METHOD
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Sobolev Spaces- basic concepts: Distributional derivatives, Sobolev spaces, Friedrich's Poincare inequality.Elliptic boundary value problems, Variational Formulation: Abstract variational formulation, Ritz formulations, Weigheted Residual Methods, Lax-Milgram lemma, Examples of second order and fourth order boundary value problems.
Finite Element Formulation: Basic aspects of the finite element method, construction of finite element spaces, Definition and examples of finite elements.
Convergence Analysis: Galerkinorthogonality property, Cea's lemma, Polynomial interpolants, Error estimates, Aubin-Nitsche duality arguments, L2 error estimates.
Computation of finite element solutions: Element stiffness matrices, Global stiffness matrix, Assembly, Solution.
Vartiational Crimes: Isoparametric finite elements, Discontinuous finite elements.
Parabolic initial and boundary value problems: Semi-discrete Galerkin finite element methods for parabolic problems, Completely discrete schemes, Error estimates.
Text Books
1. Brenner S. C., Scott, L. R., The Mathematical Theory of Finite Element Methods, 2nd edition, Springer, 2002.
2. Reddy, J. N., An Introduction to Finite Element Method, McGraw Hill, 1993.

Reference Books
1. Ciarlet, P. G., The Finite Element Method for Elliptic Problems, North-Holland, 1978.
2. Johnson, C., Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.

Course Code:SCL 618
Course Title: THEORY OF FLUID MECHANICS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Fundamental Equations of motions: Equations of continuity, momentum & energy for a fluid flow; Reynolds' principles of similarity from the Navier- Stokes equations; Limiting cases of large and small viscous forces.
Exact solutions of Navier-Stokes Equations in some special cases, like flow through a straight channel and Couette flow; Poiseuille flow through a pipe, Stokes problems
Laminar boundary layers: Approximations and derivation of boundary layer equations; Separation of boundary layers; Integration of boundary layers; General properties of boundary layer equations.
Compressible flow, Thermodynamic relations of perfect gases, speed of sound, pressure field, Basic equations for one-dimensional flow;

Conservation laws, Characteristics, shock waves and expansion waves, Riemann Problem, CFL condition, Duct Flows.

Text Books

1. Anderson J. D., Modern Compressible Flows, McGraw Hill, 1989
2. Chorin, A. J., Marsden, J. E., A Mathematical Introduction to Fluid Mechanics, 3rd ed., Springer-Verlag, 1993

Reference Books

1. Batechelor, G. K., An Introduction to Fluid Dynamics, Cambridge Press. 2002
2. Som S. K., Biswas G., &Chakraborty S., Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill Education; 3 edition (2017).
3. Landau L. D., Lifshitz E.M., Fluid Mechanics, Pergamon Press, 1989.

Course Code: SCL619
Course Title: MATHEMATICAL METHODS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Complex Variable: Complex Algebra, Cauchy Riemann Conditions, Cauchy's Integral Theorem, Cauchy's Integral Formula, Laurent Expansion, Mapping, Singularities, Calculus of Residues.

Differential equations: Partial Differential equations, Separation of Variables, Special functions, Orthogonal Polynomials.

Symmetry of differential equations: One-parameter groups on the plane, Group generator, Lie equations, Symmetry group, Group transformations, Invariants.

Text Books

1. Kreyszig E. Advanced Engineering Mathematics. John Wiley & Sons, 9th edition, 2013.
2. Bluman, G., Kumei, S., Symmetries and Differential Equations, Springer, New York, 1989.

Reference Books

1. Brown J. W. and Churchill, R.V. Complex Variables and Applications, McGraw-Hill Education, 9th Ed., 2013.

Course Code: SCL620
Course Title: BIOMECHANICS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Application of Statics to Biomechanics:Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle.Basic assumptions andlimitations.

Deformable body Mechanics:Applied forces and Deformations, internal forces and moments, Stress and Strain, Basic loading configurations, Uniaxial tension test, Load- elongation diagrams, Hooke's Law, Work and Strain Energy, Properties based on Stress-strain Diagrams, Idealized model for material behavior and Mechanical properties of materials.

Multi axial Deformation and stress analysis:Poisson's ratio, Biaxial and tri axial stresses, Failure theories, allowable stress and factor of safety, Fatigue and endurance, Torsion, Bending and combinedloading.

Mechanical Properties of Bone and Soft Tissues:Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Remodeling, Biomechanics of Tendon and Ligaments. Biomechanics of Skeletal Muscles.

Text Books

1. Fung Y.C., Biomechanics: Mechanical Properties of Living Tissues, Springer Verlag, 1981.
2. Frankel V.H., Nordin M., Basic Biomechanics of the Skeletal System, Lea &Febiger, 1980.

Reference Books

1. Winter.D.A., Biomechanics and Motor Control of Human Movement, John Wiley & Sons, 2009.
2. NihatOzkaya and Margareta Nordin Fundamentals of Biomechanics, 3rd Edition. VNR, Springer, New York, 2012.

Course Code: SCL621
Course Title: BIO-FLUID MECHANICS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Introduction to Fluid Mechanics:Fluid properties, basic laws governing conservation of mass momentum and energy; Laminar flow, Couette flow and Hagen-Poiseuille equation, turbulent flow.

Bio-fluid Dynamics:Blood system network and physiology, blood rheology, Vessel structure and mechanical properties Lymphatic system; Body fluids and their motions; Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.

Cardio-vascular system:Heart and pumping process, Blood flow in body, Flow dynamical study of circulatory system, heart and blood vessels, anatomy and physiological considerations; Components and functions of arterial and venous systems: Blood flow through arteries and veins.

Models for physiological flows:Physiology, Physiological Flows; The Krogh model of Oxygen diffusion from blood vessel to tissue; Fluid flow in Kidney; Peristaltic flow models for various physiological systems; Computational simulations of physiological flows.

Text Books

1. Mazumdar J.N., Bio-fluid Mechanics, World Scientific, 1992.
2. Fung Y.C., Biomechanics: Motion, Flow, Stress, and Growth", Springer-Verlag, 1990.

Reference Books

1. Berne, R.M., Levy, M.N., Cardiovascular Physiology, 8th Edition, Mosby, 2001.

Course Code: SCL622
Course Title: SUMMABILITY AND APPROXIMATION THEORY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Transformation:Matrix and Linear Transformation.Summability Means: Definition of Summability, Summation of series by arithmetic means, Cesàrosummability and Abel summability of Fourier series, Nörlund method, Euler means, Riesz's Typical means, Hölder means of order K, Regularity of Transformation, Consistency of methods, Inclusion theorem for Nörlund method, Equivalent methods, Almost everywhere summability, Strong summability.

Function of L^p class, Norm, Minkowsky and Hölder inequalities, Bessel's inequality, Second mean value theorem, Best Approximation in normed Spaces, Trigonometric Fourier Approximation,Bernstein polynomials,Weierstrass Approximation Theorem.

Text Books

1. Hardy , G. H., Divergent Series, Clarendon Press, Oxford,1967.
2. Peterson, G. M., Regular Matrix Transformation, Mc-Graw Hill

Reference Books

1. Zygmund, A., Trigonometric series Vol. 1, Cambridge University Press, 1959.
2. Titchmarsh, E.C., Theory of Functions, Oxford University Press, 1939.

Course Code: SCL 623
Course Title: SYMMETRIES AND DIFFERENTIAL EQUATIONS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:

Lie Groups of Transformations:Groups, Groups of Transformations, One-Parameter Lie Group of Transformations,

Infinitesimal Transformations:First Fundamental Theorem of Lie, Infinitesimal Generators, Invariant Functions, Canonical Coordinates,

Examples of Sets of Canonical Coordinates, Invariant Surfaces, Invariant Curves, and Invariant Points.

Ordinary Differential Equations:Invariance of an Ordinary Differential Equation, First Order ODE's, Determining Equation for Infinitesimal Transformations of a First Order ODE, Determination of First Order ODE's Invariant Under a Given Group, Second and Higher Order ODE's, Reduction of Order by Differential Invariants, Determining Equations for Infinitesimal Transformations of an nth Order ODE, Determination of nth Order ODE's Invariant Under a Given Group, Applications to Boundary Value Problems for ODE's.

Partial Differential Equations:Invariance of a Partial Differential Equation, Invariant Solutions, Mapping of Solutions to Other Solutions from Group Invariance of a PDE, Determining Equations for Infinitesimal Transformations of a k^{th}Order PDE, Invariance for Systems of PDE's, Determining Equations for Infinitesimal Transformations of a System of PDE's, Applications to Boundary Value Problems for PDE's.

Text Books

1. Bluman, G. W., Kumei, S., Symmetries and Differential Equations, Springer, New York, 1989.
2. Bluman, G. W., Cole, J. D., Similarity Methods for Differential Equations, Springer, New York, 1974.

Reference Books

1. Bluman, G. W., Anco, S. C., Symmetry and Integration Methods for Differential Equations, Springer, New York, 2002.

Course Syllabi (Ph.D.)
Department of Mechanical Engineering

Course Code: MEL 601
Course Title: ENERGY CONSERVATION AND WASTE HEAT RECOVERY
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Introduction to Waste Heat, Importance of Waste Heat Recovery, Review of Thermodynamics. Introduction to First and Second Laws. Review of Thermodynamics: Entropy, Entropy Generation, First and Second Law efficiency. Power Plant Cycles - Energy Cascading, Rankine Cycle, modification of Rankine cycle. Gas Turbine Cycle, Combined Cycle, Combined Gas Turbine-Steam Turbine Power Plant, Heat Recovery Steam Generators**.** Thermodynamic cycles for low temperature application, Cogenerations, Introduction to Heat Exchangers, Analysis – LMTD and ε-NTU method. Analysis of Heat Exchanger: continued, Problem solving, Special Heat Exchangers for Waste Heat Recovery, Synthesis of Heat Exchanger Network. Heat pipes & Vapor Chambers, Direct conversion technologies: Thermoelectric Generators. Direct conversion technologies: Thermoelectric Generators, Thermoionic conversion, Thermo-PV, MHD. Heat Pump; Heat Recovery from Incinerators, Energy Storage: Introduction. Energy Storage Techniques: Pumped hydro, Compressed Air, Flywheel, and Superconducting Magnetic storage. Energy Storage Techniques: Thermal storage (Sensible & Latent), Battery, Chemical Energy Storage, Fuel cells. Energy Economics.
Text Book:
1. Taimoor Pervez, Waste Heat Recovery and Energy Conservation of Arl Distillation, 2011.

Course Code: MEL 602
Course Title: HEAT EXCHANGERS: FUNDAMENTALS AND DESIGN ANALYSIS.
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Background, Application, Classification, Common terminologies. Introduction to Thermal and hydraulic aspects, pressure drop and heat transfer, sizing and rating. LMTD and NTU method. Tubular Heat Exchangers: different designs, brief description of Shell and Tube Heat Exchangers, Special types. Compact heat exchangers, enhancement of heat transfer, extended surface or Fin, fundamental of extended surface heat transfer, Fin tube heat exchanger. Plate Fin Heat Exchangers (PFHE), types, construction, fabrication, design, application. Multistream PFHE. Multistream PFHE continued. Direct contact heat exchangers, types, application, simple analysis. Regenerators, types of regenerators, construction, application. Theory of Regenerator, Heat pipes, construction, working principle, application, analysis. Special heat pipes. Microscale Heat Exchangers and heat sinks; heat transfer and fluid flow through narrow conduits, special design considerations. Phase change HEX; phase change heat transfer, introduction to evaporators and condensers. Phase change HEX; phase change heat transfer, introduction to evaporators and condensers. Heat Exchanger testing, steady state and dynamic methods.
Text Book:
1. Fundamentals of Heat Exchanger Design by R. K. Shah, Dusan P. Sekulic, John Wiley & Sons,2003.

Reference Books:
1. Heat Exchanger Design Handbook by Kuppan Thulukkanam, Taylor & Francis, 2000.
2. Heat Exchangers: Selection, Rating, and Thermal Design, Third Edition by Sadik Kakac, Hongtan Liu, CRC-Press 1998.
3. Cryogenic Heat Transfer, Second Edition by Randall F. Barron, Gregory F. Nellis, CRC Press, 2016.

Course Code: MEL 603
Course Title: ADVANCED MATERIALS AND PROCESSES
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Introduction to metastable and functional alloys, Bulk Metallic glasses Part I: Fundamental concepts. Bulk Metallic glasses Part II: Mechanical and Functional properties. Shape memory alloys and Pseduelasticity. Shape memory alloys: Applications and case studies, Introduction to high temperature materials. Superalloys: Alloy design, Microstructure and Properties. Nano-materials Part I. Nano-materials Part II. Soft and hard magnetic materials, Non-equilibrium Processes, Single Crystal Growth, Rapid Solidification, Inert Gas Condensation, Advanced Functional Alloys.
Text Books:
1. Jaluria, Yogesh, Advanced Materials Processing and Manufacturing, Springer, 2018.

Course Syllabi (Ph.D.)
Department of Physics

Course Code: SCL601
Course Title: SYNTHESIS OF MATERIALS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Crystallographic and Microstructural Considerations, Chemical Energetics and Atomistics of Reactions and Transformations in Solids Synthesis Methodologies: Sol-gel, Solvothermal and Hydrothermal Techniques, Solid state diffusion, co-precipitation, combustion, chemical solution, Template based synthesis, Microwave assisted, CVD, PVD, Molecular beam epitaxy, Vapor (solution)-liquid-solid growth, (VLS or SLS), Spray pyrolysis, Spin coating, chemical evaporation, thermal evaporation, electron evaporation, pulse vapour diffusion, Electro-deposition process, Lithography.
Text Books:
1. Lalena, J. N., Cleary, D. A., Carpenter E., Dean N. F., Inorganic materials synthesis and fabrication, John Wiley & Sons, Inc., Publication, 2008.
2. Poole, C.P., Owens, F.J., Introduction to Nanotechnology, Wiley, New York, 2003.

Reference Books:
1. Bradley, D. F., Materials Chemistry, Kindle Edition, 2008.
2. Guozhong, Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press 2004.

Course Code: SCL602
Course Title: CHARACTERIZATION TECHNIQUES
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
X-Ray Diffraction Method, Neutron Diffraction, Electron Diffraction-diffraction pattern in specific modes, LEED and RHEED, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing AES and EDX techniques, Vibrating Sample Magnetometer (VSM). NMR, TGA-DTA, DSC, FTIR, Raman, Absorption, PL, EL, CL, OSL, X-Ray spectroscopy, X-ray photoelectron spectroscopy, J-V-L, Cyclic voltammetry, Spectroscopic ellipsometry, Electrical measurements, VSM, SQIUD.
Text Books:
1. Sam Zhang, Lin Li, Ashok Kumar, Materials Characterization Techniques, CRC Press, 2008.
2. Michael Sayer, Abhai Mansingh, Measurement, Instrumentation and Experiment Design in Physics and Engineering, Phi Learning Pvt. Ltd., 1999.

Reference Books:
1. W. Altergott, E. Henneke, Characterization of Advanced Materials, Springer, 1990.
2. David Brandon , Wayne D. Kaplan, Microstructural Characterization of Materials, 2nd Edition, Wiley.

Course Code: SCL603
Course Title: PHYSICS OF MATERIALS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Classification of materials, Structure of crystalline solids, Electrical proeperties: Electrical Conductivity, Ionic conduction, Energy band structures in solids, electrical resitivity of materials, electrical charrectirization. Thermal properties: Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses. Optical properties: Refraction, reflection, absorption, transmission, colour, opacity, translucency, luminescence, photoconductivity, optical fibers, Magnetic properties: Dimagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism and ferrimagnetism, Effect of temperature on magnetic behavior, Mechanical properties: Types of metal alloys, deformation. Processing and fabrication of materials.
Text Books:
1. Callister, W. D., by Raghwan, Fundamentals of Materials Science and Engineering, Wiley, 2007.
2. Pillai, S. O., Solid State Physics, 6th Ed., New Age International, New Delhi,2010.

Reference Books:
1. R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley, 2013.
2. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology, Wiely India Pvt. Ltd. 2016.
3. Raghwan, V., Material Science and Engeenearing, Prentice Hall, India, 5th Ed 2007.
4. Kittle, C., Introduction to Solid State Physics, Wiley, 2007.
5. Rohrer, Structure and Bonding in Crystalline Materials, Cambridge University Press, 2001.
6. Hassen, P., Material Science and Technology, Volume 5, Phase Transformation in Materials.

Course code: SCL611
Course Title: MAGNETISM AND SPINTRONICS
Structure (L-T-P): 3-0-0-3
Pre-requisite: NIL
Contents:
Introduction and basics of magnetism, type of magnetic materials, Classical and quantum theories. Exchange interactions, magnetic ordering and domains, spin waves. Various forms of magnetic energies, Magnetic anisotropy. Soft and hard magnetic materials. Magnetism in thin films, muiltilayers and fine particles, Superparamagnetism. Anisotropic magnetoresistance, Giant magnetoresistance, Tunnel magnetoressistance, Colossal magnetoresistance, Basics of spin polarized transport and spintronics. Spin-Orbit interactions, Hall Effect, Anomalous Hall Effect, Spin Hall Effect. Magnetism in insulators & semiconductors, dilute magnetic semiconductors, Multiferroics, Heuslor alloys. Spin injection phenomena. Magneto-optics: Kerr and Faraday Effect.
Text books:
1. Spaldin N.A., Magnetic Materials, 2nd Edition, Cambridge University Press, 2011.
2. O'Handley R. C., Modern Magnetic Materials, John Wiley & Sons, Inc., 2000.
3. Tsymbal E. Y. and Zutic I., Handbook of Spin Transport and Magnetism, CRC Press, 2012.

Reference books:
1. Blundell S., Magnetism in Condensed Matter, 1st Edition, Oxford University Press, 2001.

2. Cullity B. D. and Graham C. D., Introduction to Magnetic Materials, 2nd Edition, 2009.
3. Shinjo T. (Editor), Nanomagnetism and Spintronics,1st edition, Elsevier, 2009.

Course code: SCL612
Course Title: THIN FILMS AND NANOSTRUCTURES
Structure (L-T-P): 3-0-0-3
Pre-requisite: Nil
Contents:
Low-dimensional materials: 0D, 1D and 2D, density of states, Size and surface effects on physical properties. Kinetic theory of gases, mean free path, gas impingement rate, monolayer formation time. brief introduction to vacuum pumps and gauges, synthesis methods for nanomaterials, Nucleation & Growth phenomena, capillarity theory, atomistic and kinetic models of nucleation, Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms and yield, dc, rf and magnetron sputtering, Bias sputtering, reactive sputtering, Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, plasma enhanced CVD, PLD, ALD, basic modes of thin film growth, stages of film growth & mechanisms, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, scope of devices and applications
Text Books:
1. Ohring M., The materials science of thin films, 2nd edition, Academic press, 2002.
2. Chopra K.L., Thin film phenomena, 1st edition, McGraw Hill, 1969.
3. Chapman B., Glow discharge processes: Sputtering and Plasma Etching, 1st edition, Wiley, 1980.
Reference Books:
1. Holland L, Vacuum deposition of thin films, 4th edition, Chapman and Hall, 1966.
2. Goswami A., Thin Film Fundamentals, New Age International Pvt. Ltd., 2008.
3. Rao M.S.R. and Singh S., Nanoscience and nanotechnology: Fundamentals to frontiers, 1st edition, Wiley, 2017.
4. Pradeep T., NANO: The Essentials, Tata McGraw Hill India, 2007.

Course code: SCL613
Course Title: X-RAY SPECTROSCOPIC TECHNIQUES
Structure (L-T-P): 3-0-0-3
Pre-requisite: Nil
Contents:
Scattering of X-Rays: Review of crystallography, nature of x-rays, generation of x-rays, spectra, Interaction of EM radiation with matter, absorption. X-ray Diffraction (XRD): Bragg's law, Intensity of diffracted beams, form factor, structure factor. Various geometries of X-ray Diffraction: powder and grazing incidence. X-ray reflectivity to characterize the surface and interfaces of thin films. Small angle x-ray scattering (SAXS), Advantage of using synchrotron radiation for material characterization. Photoelectron Spectroscopy: X-ray photoemission spectroscopy (XPS), Angle Resolved XPS (ARPS), Valance Band Spectroscopy (VBS), Auger Spectroscopy. X-ray Absorption spectroscopy: Near Edge and Extended X-Ray Absorption Fine Structure (XANES and EXAFS), Transmission and Fluorescence method of detection. X-ray Magnetic Circular Dichroism (XMCD). Application of X-ray based techniques in characterization of soft-matter, thin films and nanomaterials.
Text Books:
1. Cullity B.D. and Stock S.R., Elements of X-ray Diffraction, 3rd Edition, Pearson, 2001.
2. Leng Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley, 2013.
3. Bunker G., Introduction to XAFS, 1st edition, Cambridge University Press, 2010.
Reference Books:
1. Verma H.R., Atomic and Nuclear Analytical Methods, 1st edition, Springer, 2007.
2. Hippert F., Geissler E., Hodeau J.L., Lelièvre-Berna E. and Regnard J.-R., Neutron and X-ray Spectroscopy, 1st edition, Springer, 2006.
3. Lovesey S.W. and Collins S.P., X-ray Scattering and Absorption by Magnetic Materials, 1st edition, Clarendon Press, 1996.
4. Watts J.F. and Wolstenholme J., An Introduction to Surface Analysis by XPS and AES, Wiley, 2003.
5. Suryanarayana C. and Norton M. G., X-Ray Diffraction, 1st edition, Springer, 1998.
6. Hüfner S., Photoelectron Spectroscopy, 3rd edition, Springer, 2003.

Course code: SCL614
Course Title: THEORETICAL METHODS IN CONDENSED MATTER PHYSICS
Structure (L-T-P): 3-0-0-3
Pre-requisite: Nil
Contents:
Electronic Structure: Single electron Model: Basic Hamlitonian, Densities of States, Statistical mechanics of non interacting electrons, sommerfield expansion: specific heat of non interacting electrons at low temperatures Schrodinger equation and Symmetry: Translation Symmetry-Bloch's theorem, vanhove singularities, Fourier analysis of Bloch's theorem, Kronney penney model
Rotational Symmetry: classes and characters, consequences of point group symmetries for Schrodingers equation. Nearly free and tight bound electrons: Nearly free electrons- Degenerate perturbation theory, Brillouine zones-Nearly free electron Fermi surfaces.
Tight bound electrons: Wannier functions and tight binding model. Electron Interaction, Hartree-Fock equations: Hartree –fock equations, numerical implementation.
Density functional theory: Thomas Fermi theory and Kohn-sham equations. Calculations of Band Structure: Numerical methods: Psuedopotentials and orthogonal Plane wave, LCAO, Plane waves, LAPW, LMTO, Brief survey of Periodic table.
Text Books:
1. Marder, M.P., Condensed Matter Physics, 21st Ed., Wiley Interscience, 2000
2. Ashcroft, N.W., Mermin, N.D., Solid State Phyics,1st Ed.,
Reference Books:
1. Katsnelson, A.A., Stepanyuk, A.S., Szasz, A., Farberovich, O.V., Computational Methods in Condensed Matter: Electronic Structure, American Institute of Physics, 1992.
2. Wong, S.S.M., Computational Methods in Physics & Engineering, 2nd Ed., World Scientific, 1997.