A: Environmental and Microbial Biotechnology

B: Parasitology and Vector Biology

C: Bioinformatics and Computational Biology

Course content of each area is given below.

A: Environmental and Microbial Biotechnology

Content:
Microbial evolution; Chemical and molecular methods for microbial identification; microbial systematics and molecular taxonomy; Plant growth promoting microorganisms and mechanisms of colonization; Biocontrol; Microbial metabolism, Genetics of microorganisms; Factors determining microbial ecology, culture-dependent & independent analysis of microbial communities, molecular typing & DNA finger-printing, metagenomics& functional metagenomics, secretomics, stable isotope probing; Sociobiology of microorganisms: quorum-sensing, biofilm; Techniques used for study of host-microbe interaction (IVET, STM, DFI); Synthetic microorganism. Molecular biology and biotechnological application of Achaea.

Basic concept of environment and its component; Definitions and facts related to Environmental

B: Parasitology and Vector Biology:

Content:
Life cycle of parasite (Plasmodium, Trypanosoma, Leishmania, Toxoplasma, Entamoeba, Giardia), and their vectors (Mosquitoes, Sandfly, Tsetse fly); Mosquito borne viruses (Dengue, chikungunya). Taxonomy and identification of parasites and vectors; Molecular biology of parasite and vector (with special emphasis to Plasmodium-Anopheles, Dengue-Aedes); Cellular and humoral mechanisms involved in immunity to parasites; Immunomodulation in vectors; Vector parasite interactions and control strategies - Disease symptoms, Molecular approaches to diagnosis, Epidemiology, drug targets, vaccine strategies and proteomic approaches, prophylaxis, treatments to parasitic diseases and vector control measures, mechanisms of drug resistance in parasites or vectors.

Drosophila life cycle & molecular aspects may also be included as a comparative to what is known about the Anophelines & Culicines.

C: Bioinformatics and Computational Biology
Content:

Introduction to genomic & Proteomics, Structural genomics and proteomics, Human Genome project and other sequencing projects, Biological databases and data mining, sequence similarity search and sequence alignment, Protein structure prediction and structure analysis, use of software package in Bioinformatics. Biomolecular Conformations, protein folding, Forcefield, Simulation, Conformational analysis, ab initio structure prediction, comparative modeling, lattice models, usage of modeling packages.

D: Plant Biotechnology

Content:

Plant tissue culture history; Requirements to grow in vitro plants; Micro propagation, its applications and limitations; Haploid production; Meristem culture; Somaclonal variations; Somatic hybridization: Protoplast isolation and culture; somatic hybrids production; Storing plant genetic resources; Secondary metabolites.

Genetic transformation of plants; Agrobacterium mediated transfer; Ti plasmid technology; Direct gene transfer methods; Vectors for plant transformation; Molecular markers (RFLP, RAPD, AFLP, SNPs, VNTR); Designing of promoters; Stress Biology; Regulation of expression of wheat and rice seed storage protein genes, regulation and evolution of the patatin genes of potato; expression of genes controlling fatty acid biosynthesis; manipulation of cereal protein and oilseed quality, genetic manipulation of pest resistance, plant disease resistance, strategies for engineering stress tolerance, strategies for improvement of crop yield and quality; Starch, polyfructans, bioplastics, the oleosin system, custom made antibodies, edible vaccines; Public concerns over GM crops and government regulations.

E: Human Diseases and Immunology

Content:

Overview of Cardiovascular Diseases (Cardiomyopathies, Hypertension, Atherosclerosis and Stroke) Including Basic Understanding of Molecular and Physiological Aspects, Molecular Basis of Diabetes Type II; Neurological disorders: Basic Molecular Understanding of Parkinson's and Alzheimer's Disease -- Cause, Physiological Aspects and Novel Therapies.

Cancer Classification Based on Origin, Markers and Histology; Mechanisms of Viral Oncogenesis; Proto-oncogenes (src, myc, ras and abl) & Tumor Suppressor Genes (Rb, P53); Growth Factors and Receptors: EGFR, PDGFR, IGFR, Integrin, Receptor Hyper-activation; Signal Transduction: PI3K-Ras-Akt, Jak/Stat, Wnt, NFkB, TGFβ; Immuno-evasion Strategies;
Molecular Mechanism of EMT and Metastasis; Apoptosis (Extrinsic and Intrinsic), Telomerase and Cancer; Anti-cancer Drug Targets.

Cell Mediated and Humoral Immunity, Antigens, Antibodies, MHC, Molecular basis of T and B cell antigen recognition and activation, Hypersensitivity, Immunity to Microbes, Immunological Tolerance, Major Cytokines, Complement system, Autoimmunity (including Type I Diabetes), Immunodeficiency, Transplantation, Basic Concepts in Vaccination.

F: Biochemistry

Content: Organization of cells; Biomolecules (proteins, carbohydrates, lipids, nucleic acids); Enzymes: structure, isolation/purification, kinetics and mechanism of action; Biochemical energetics; Metabolic pathways: Carbohydrate metabolism, Biological oxidations, Lipid metabolism, Photosynthesis, Metabolism of nitrogen.

Physical principles in the biological and biomimetic molecular systems; Conformational and energetical properties of biomolecules like amino acids, proteins, nucleotides, nucleic acids as well as biomimetic systems like monolayers and bilayers; Related physical phenomena in these systems like structural transitions, protein folding, membrane equilibria; Principles of major experimental techniques applied to understand these physical problems.

G: Molecular Biology and r-DNA technology

Content: Eukaryotic chromosome and its Organization (Chromosome and chromatin structure the Content of Genome, Clusters and repeats); DNA replication (Prokaryote and eukaryote), Transcription, its control and post-transcriptional modifications; Translation, its control and post-translational modifications; Regulation of gene expression in prokaryotes and eukaryotes (Epigenetic modifications like DNA methylation Histone methylation, acetylation and phosphorylation, DNA binding domains, Zinc fingers, steroid receptors, leucine zipper, Yeast GAL genes) Eukaryotic cell cycle control and regulation (basic regulation of cell cycle, Signal transduction pathways: MAP-Kinase Jak-Stat, PI3Kinase, Notch, Wnt and Integrin/E-Cadherin); Phage Strategies (Control of lytic cascades in T4, T7 and lambda phage, Maintenance of lysogeny, Repressor synthesis and binding, Balance between lysogeny and lytic cycle); Regulatory RNA Biology (Riboswitch, Regulate gene expression by noncoding RNA, Attenuation and regulation by small RNA molecules, Gene silencing and RNA interference, antisense RNA)

Plasmids as cloning vehicles; plasmid copy number control mechanism, Cosmids; Restriction enzymes, Ligation, Linkers, Adaptors Homo -polymer tailing; Different cloning strategies in gram negative and gram positive bacteria; Screening of Recombinant molecules; Expression vectors and protein purification; PCR, Reverse transcription-PCR (RT-PCR); Site directed mutagenesis; Nucleotide sequencing; Basic Techniques in Recombinant DNA Technology with emphasis on
Electrophoresis, Blotting Techniques (Western, Southern, Northern Blotting), DNA and protein microarrays, DNA mediated transformation, viral transduction and electroporation.

H: Animal Biotechnology

Content:
Cell and Tissue Culture: Uses, Advantages and Disadvantages; Primary Cell Culture; Characteristics of Cells in Culture; Sterilization & Media Preparation; Development and Maintenance of Cell Lines; Transformation & Immortalization; Cryopreservation; 3D Culture Method; Tissue Engineering; Cell Based Assays (Principle and procedure: Viability, Cytotoxicity, Staining and Visualization, Flow Cytometry); Scaling Up; Therapeutic & Biotechnological Aspects of Cell Culture.

Basic Characteristics and Isolation of Embryonic Stem Cells, Adult Stem Cells; IPSCs; Molecular and Transcriptional Control of Stem Cells (cytokines, growth factors and transcription factors); Therapeutic and Reproductive Cloning; Stem Cell Plasticity, Stem Cell Niche, Cancer Stem Cells, Stem Cell Culture, Current Aspects of Stem Cell Therapy.

Life Cycle and Development of Mouse and Zebra Fish; Classical Transgenic Production (pronuclear microinjection and blastocyst injection); Mouse Knock-out, Knock-in, Gene Trap, Hypomorphic and Conditional Knockout Strategies. Identification and Utility of Major Mouse Strains (congenic, syngenetic and allogenic), Genetic Backgrounds in Mice; Zebrafish Transgenesis-Development and Methods.
Sub-area - Inorganic chemistry

The areas of Ph.D qualifying in inorganic chemistry should cover the topics of inorganic chemistry such as, coordination chemistry, reactions, kinetics and mechanism; advanced organometallic chemistry, bonding models in inorganic chemistry, inorganic chains, rings, cages and clusters; group theory and its applications to crystal field theory, molecular orbital theory and spectroscopy (electronic and vibrational); inorganic chemistry in biological systems. It may contain the basics of solid state chemistry, comprehensive survey of different synthesis techniques, properties and their structural-property relationship of solid materials; introduction to special nanomaterials, ceramics, polymers, biopolymers and nanocomposites; thermal and mechanical properties of nanomaterials; nanocomposites in hydrophobic applications; recent advances in material science and technology. A comprehensive survey of the catalytic processes along with the fundamental aspects of the catalyst design and evaluation; several classes of heterogeneous industrial catalysts; their preparation, characterization and applications, recent developments in catalysis, application of nanomaterials in catalysis could be covered. Bioinorganic chemistry, fundamentals of toxicity and detoxification, chelating agents and metal chelates as medicines. Advanced spectroscopic techniques used in chemistry. Some topics in environmental chemistry, like green chemistry, ozone chemistry, effect of SOx and NOx as pollutants, water pollution and treatment, organochlorine and organophosphate pesticides, ecosystem effects, toxic chemicals – Effect of dioxins, polychlorinated biphenyls (PCBs) and species of metals such as lead, mercury, cadmium etc.

Sub-area - Analytical chemistry

The areas of Ph.D qualifying in analytical chemistry should cover principle, techniques and applications of conventional methods of gas chromatography, ion chromatography, high performance liquid chromatography (HPLC), mass spectrometry (ionization techniques, various mass-spectrometer, tandem mass-spectrometry, ion cyclotron resonance), electroanalytical chemistry, thermo analytical techniques (TGA and DSC), atomic absorption techniques, sample preparation and injection techniques (including flow injection analysis) for analysis of chemical and biological contaminants (environmental analytical chemistry); bio-analytical techniques such as fluorescence and chemiluminescence, electrophoresis, miniaturized (micro/nano) analytical devices, lab on chip techniques and their applications. It will also include data analysis, classical analysis and separation techniques. Various spectroscopic techniques included will be rotational spectroscopy (rotational energy levels for various systems, determination of structural parameters from rotational spectroscopy, distortion constants), nuclear magnetic resonance spectroscopy (Fourier transform NMR, NOE, Multipulse methods, 2D-NMR), vibrational spectroscopy (normal mode description, symmetry of normal modes, transition moment integrals, functional group determination, overtones, anharmonicity), electron absorption spectroscopy of organic and inorganic compounds (application of group theory, selection rules, Franck-Condon factor), electronic paramagnetic spectroscopy/nuclear quadrupole resonance spectroscopy/Mossbauer spectroscopy (theory and important applications), determination of magnetic properties, photoelectron spectroscopy, microscopic techniques (TEM-STM-AFM), X-Ray crystallography. Environmental analytical chemistry - wastewater treatment and evaluation.
of analytical parameters such as COD, BOD, etc, speciation. Radioanalytical techniques such as liquid scintillation counting, isotope dilution analysis and neutron activation analysis.

**Sub-area - Physical chemistry**

The laws of thermodynamics, applications to phase equilibrium, reaction equilibrium, and electrochemistry; review of ensembles, fluctuations, Boltzmann statistics, quantum statistics, ideal gases and chemical equilibrium, imperfect gases, distribution function theories and perturbation theories of classical liquids, electrolyte solutions, kinetic theory of gases, continuum mechanics, Boltzmann equation, transport processes in gases and Brownian motion, introduction to time-correlation function formalism.

Principles and techniques of quantum mechanics, applications to atomic and molecular structure and spectroscopy, molecular interactions, macromolecules, solid state; groups, subgroups and classes: definitions and theorems, molecular symmetry, character tables, wave functions as bases for irreducible representations, direct product, symmetry adapted linear combinations, symmetry in molecular orbital theory, hybrid orbitals.

Molecular motion in gases and liquids, reaction rate laws, mechanisms and rate theories of complex reactions, molecular reaction dynamics, surface processes, electron transfer dynamics.

Solid state chemistry, different synthesis techniques, introduction to special nanomaterials, ceramics, polymers, biopolymers and nanocomposites, thermal and mechanical properties of nanomaterials, nanocomposites in hydrophobic applications, recent advances in material science and technology.

Electronic absorption spectroscopy, optical rotatory dispersion and circular dichroism, vibrational rotational spectroscopy, magnetic resonance techniques, multipulse methods, Mossbauer spectroscopy, magnetism, ionization methods: mass spectrometry, ion cyclotron resonance, photoelectron spectroscopy; electron microscopy technique, X-ray fluorescence and near edge structure, X-ray crystallography; fluorescence and phosphorescence, physical properties of molecules after photoexcitation, photochemical tools and techniques, fluorescence decay time measurement and analysis, flash photolysis, fundamental properties of laser light, principles of laser operation and applications.

Nuclear chemistry and its applications.
Sub-area - Organic chemistry
Covers all major topics of organic chemistry at advanced level and current research fields. This includes total synthesis, reagents for organic synthesis, synthetic method development, catalysis, organometallic chemistry, heterocyclic chemistry, green chemistry, natural product chemistry, medicinal chemistry, organic photochemistry, bio-organic chemistry, stereochemistry, spectroscopy-basic principle and applications, separation techniques, supramolecular chemistry, organic smart materials, dyes and pigments, organic polymers, drug discovery and developments and, organic chemistry in industry. However, “organic chemistry” is not limited to above mentioned topics only but includes other newly developed areas of organic chemistry.

Sub-area – Theoretical and computational chemistry
The areas of Ph.D qualifying in theoretical and computational chemistry should cover three broad area’s Electronic Structure Theory, Chemical Applications of Group Theory and computational material science. Topics to be included in these three area’s will be


Chemical Applications of Group Theory: Basic concepts of groups, Molecular symmetry, point-groups and character tables, Applications in quantum chemistry – symmetry adapted linear combination of orbitals, vanishing integrals, spectroscopic selection rules for rotational, vibrational and electronic transitions, applications in physical properties – dipole moments, optical activity, etc.

Computational Material Science: Modern materials modeling including quantum chemical methods, density functional theory, semi-empirical and classical approaches, statistical mechanics, atomic-scale simulations. Application of density functional methods to hybrid, multifunctional and nanomaterials. Methods for analyzing electronic (optical), structural and transport properties of these materials.

This topic will also include computational photochemistry and reaction dynamics of organic and inorganic systems, molecular simulation, thermodynamic and transport properties of liquid mixtures, computational statistical mechanics and numerical methodologies.
Qualifying areas for Mathematics: Approved by all campuses

- **Algebra**: Commutative Rings, Non-commutative Rings, Groups and their Representations, Field Theory, Module Theory, Homological Algebra, Number Theory and Algebraic Geometry.

- **Analysis**: Real Analysis, Complex Analysis, Functional Analysis, Nonlinear analysis, Differential Geometry.


- **Numerical Methods and Applications**: Numerical methods for Ordinary, Partial and integro-differential equations and applications to fluid dynamics and Fracture Mechanics.

Research sub-area course description (Physics)

1. Condensed Matter Physics


2. **Nuclear and High Energy Physics**:
Nuclear Physics: Rutherford Scattering, definition of the scattering cross section; nuclear size and mass, liquid drop model; Angular momentum and parity, magnetic and quadrupole momenta; Two-nucleon problem, the deuteron, tensor force; Neutron-proton scattering, phase-shift analysis, scattering length, spin-dependence; Isospin-formalism, exchange forces, NN potentials; nuclear shell model, spin-orbit coupling; Nuclear decay, alpha and beta-decay; quark model.

Particle Physics, QFT, String Theory: Klein-Gordon eqn. Maxwell's equation and Dirac eqn., symmetries and conservation laws., Relativistic kinematics of collision and decay, electron-photon interaction(QED), Scalar field theory, Dirac field theory, Yang Mills field, Interactions, Quantum Electrodynamics, Spontaneous symmetry breaking, Abelian-Higgs model, QCD, Renormalization group, Anomalies, non-perturbative configurations, instantons, Lattice gauge theories. Lie groups (U(1),SU(2),SU(3)) and algebra, Electro-weak interaction, phenomenology of QCD, Higgs mechanism, Supersymmetry and Supersymmetric field theory, Perturbative & non-perturbative aspects of string theory, Conformal field theory, Aspects of differential geometry, Topological field theory, Elements of group theory and representations. Differential geometry, calculus of variations

Numerical methods for solving ODE's, PDE's; Monte-carlo methods; Molecular dynamics simulations; Numerical methods for finding eigenvalues and eigenvectors; Numerical methods for solving linear and nonlinear equations; Numerical interpolation and integration; Fourier transforms.

3. **Optics and Spectroscopy**

Maxwell's equations, wave equation for electromagnetic radiation, light waves in matter, paraxial optics, matrix methods, two and multiple beam interference, Fresnel & Fraunhoffer diffraction, temporal & spatial coherence, image formation, polarization, crystal optics, lasers, holography, fiber optics, Nonlinear Optics, Quantum Optics

Interaction of matter with radiation, transition rates, dipole approximation, Einstein coefficients, angular momentum and selection rules, line intensities and line shapes, Doppler effect, Alkali spectra, fine structure, LS coupling, jj-coupling, Zeeman effect, Paschen-Back effect, Stark effect, hyperfine structure, rotational and vibrational spectra of diatomic and polyatomic molecules, Raman Spectroscopy, electronic spectroscopy of
molecules, Nuclear Magnetic Resonance spectroscopy, Electron Spin Resonance spectroscopy.

4. **Theoretical Physics**

Vectors and tensors, linear operators- eigenvalues and eigenstates. Discrete and continuous spectra. Delta function (and other distributions). Inverse operator and Green functions.

Group theory: Cayley's theorem, Langrange’s theorem, invariant subgroups, construction of group representations, character of group representation, Schur's lemmas, orthogonality relations, irreducible representation, adjoint representations, reduction of Kronecker products(C-G series), point symmetry groups. Continuous groups, infinitesimal transformations, structure constants, Lie algebras, Linear representation of Lie groups, irreducible representations of Lie groups and Lie algebras, Multivalued representation, Universal covering group, representations of rotation group(2-d&3-d), Irreducible representations of SU(n), U(n),Sp(n). Partial differential equations: Laplace equation, wave equation, And heat flow. Special functions: Gamma functions, Bessel functions and its variants, Legendre functions, Hermite functions, Hypergeometric functions, Confluent hypergeometric functions, Laguerre functions, Integral transforms: Fourier and Laplace transform.

Constraints and generalized coordinates, Lagrange’s equation of motion, calculus of variation and principle of least action, central force motion, kinematics of rigid body motion, rigid body equations of motion, heavy symmetrical top, Hamilton’s equations of motion, canonical transformations.

Fundamental concepts (Stern-Gerlach experiments, bra-ket vectors), Quantum Dynamics(Schrodinger and Heisenberg picture, Simple Harmonic Oscillator) Angular momentum(spín \(\frac{1}{2}\) system, angular momentum addition), Symmetry in Quantum Mechanics(conservation laws, continuous and discrete symmetries), Time-Independent perturbation theory: nondegenerate and degenerate cases, Zeeman effect and Stark effect, Time-dependent potential, the interaction picture, Identical particles, Scattering

Macro and Micro-states, Phase space, Liouville’s theorem, Microcanonical ensemble, Equipartition & Virial theorems, Canonical ensemble, a system of harmonic oscillators, Paramagnetism, Bose-Einstein and Fermi-Dirac statistics, Black-Body radiation, Specific heat, Bose-Einstein condensation.
Electric potential of charge distribution, potential of dipole, Dielectric, Electric displacement, Magneto statics, Vector potential, magnetization, bound currents, Ampere's law in magnetic material, Faraday's law, induced electric field, Energy in magnetic field, Maxwell's equations in free space and media. Poynting theorem, Conservation of momentum and angular momentum, plane waves, propagation in linear media, absorption and dispersion, Potential formulation of electrodynamics, Gauge transformations, Retarded potentials, Lienard-Wiechert potential, field of moving point charge, Electric dipole radiation, magnetic dipole radiation, power radiated by point charge, radiation reaction.

5. Quantum Physics


Quantum Optics: Quantization of the EM field, Fock space representation, thermal fields, coherent states and squeezed states, quantum coherence functions and interferometry, single photon experiments, emission and absorption of radiation by atoms.

Numerical methods for solving ODE’s, PDE’s; Monte-Carlo methods; Molecular dynamics simulations; Numerical methods for finding eigenvalues and eigenvectors; Numerical methods for solving linear and nonlinear equations; Numerical interpolation and integration; Fourier transforms.

6. Astrophysics and Cosmology

Observational Astronomy: Celestial Sphere, Astronomical Coordinate Systems, Geographical Coordinates, Horizon System, Equatorial System, Diurnal Motion of the Stars, and Measurement of Time

Cosmology: Tensors, Affine connection, covariant derivative, geodesics, Ricci scalar, Riemann tensor and Einstein equation, Friedman-Robertson-Walker metric, Standard Model of Cosmology, Cosmological Microwave Background (CMB) spectrum, Role of Dark Matter and Dark Energy.


Review of special theory of relativity, Gravity as geometry, descriptions of curved space-time, tensor analysis, geodesic equations, affine connections, parallel transport, Riemann and Ricci tensors, Einstein’s equations, Schwarzschild solution, classic tests of general theory of relativity, mapping the universe, Friedmann-Robertson-Walker (FRW) cosmological model, Friedmann equation and the evolution of the universe,
thermal history of the early universe, shortcomings of standard model of cosmology, theory of inflation, cosmic microwave background radiations (CMBR), baryogenesis, dark matter & dark energy.

Numerical methods for solving ODE's, PDE's; Monte-Carlo methods; Molecular dynamics simulations; Numerical methods for finding eigenvalues and eigenvectors; Numerical methods for solving linear and nonlinear equations; Numerical interpolation and integration; Fourier transforms.

7. Semiconductor Physics

Crystal structure and growth of semiconductor, Elementary quantum physics, Energy bands in solids, Charge carriers in semiconductors, Carrier Transport Phenomena, Non-equilibrium excess carriers in semiconductors, Continuity equation (includes setting up and solving for various boundary conditions), Fabrication of p-n junctions, equilibrium conditions, forward and reverse biased junctions, metal-semiconductor junctions, Bipolar junction transistors, Field effect transistors (JFET,MOSFET), Optoelectronic Devices (varactor diode, solar cell, LEDs, Tunnel diode, etc). IC Fabrication: Fabrication technology, Nanoscience and Nanotechnology

8. Nonlinear science and Complex systems

Phase plane analysis, Local Bifurcations in maps & differential equations, Global Bifurcations, Chaotic Dynamics, Fractals, Strange Attractors, Relaxation oscillations; Application of Bifurcation analysis to various systems; Time series analysis; Hamiltonian systems; Quantum chaos

Synchronization of periodic oscillators by periodic forces, synchronization of interacting systems with and without noise, synchronization of chaotic systems. Nonlinear dynamics in various systems - biological, social, economic, etc.

Content for PhD Qualifying Examination Sub-Areas

Research Area 1: Artificial Intelligence, Machine Learning and Data Mining

Data Mining

Need for data mining, Preprocessing: Dimensionality reduction, Missing values, Normalization & standardization, Noise and outlier detection, Data smoothening Classification: Decision tree, K-nearest neighbors, Naive Bayesian classifiers, Rule based classifiers, Support vector machine, Underfitting/overfitting, Ensemble classifiers, Classification evaluation and model selection. Association rule mining, Frequent item set mining, Apriori and its optimizations, FP-growth, Efficient Rule generation, Other measures (lift, interest etc), correlation, Hierarchy based Frequent item set mining, Clustering Type of clustering Partitioning clustering k-means, k-mediod (PAM) algorithms, Hierarchical clustering algorithms, Agglomerative algorithms--s-link, complete link, average link etc, Divisive algorithms, Density based clustering, DBSCAN, OPTICS algorithms, Grid based Clustering, Cluster evaluation.

Machine Learning


Artificial Intelligence

Problem Solving by Searching

Uninformed and informed search techniques including breadth first search, depth first search, depth limited search, iterative deepening search, Avoiding repeated states. Heuristics based searches including Greedy best first search, A* search, memory bounded heuristic search. Local search algorithms and problem solving including Hill climbing, Simulated annealing, local beam search, genetic algorithms etc. Adversarial search, alpha beta pruning, games problems.
Knowledge and Reasoning

Knowledge based agents, Propositional logic, syntax and semantics, equivalence, validity and satisfiability, forward and backward chaining, resolution. First order logic (FOL), syntax and semantics of FOL, Representation of real world domain using propositional and first order logic, Unification and lifting, quantifiers, Inference rules, conjunctive normal form for FOL, resolution for FOL. Reasoning systems for categories, semantic networks, description logic.

Uncertain knowledge and Reasoning


Learning

Inductive Learning, Decision trees, Ensemble learning, knowledge in learning, explanation based learning, statistical learning, learning with complete data, Maximum-likelihood parameter learning, Naive Bayes models, Gaussian Mixture Models, hidden Markov models, Instance based learning, Nearest neighbour models, kernel models, Kernel machines, Neural Networks models for learning, reinforcement learning.

Problem Solving by Searching

Uninformed and informed search techniques including breadth first search, depth first search, depth limited search, iterative deepening search, Avoiding repeated states. Heuristics based searches including Greedy best first search, A* search, memory bounded heuristic search. Local search algorithms and problem solving including Hill climbing, Simulated annealing, local beam search, genetic algorithms etc. Adversarial search, alpha beta pruning, games problems.
Research Area 2: Computer Architecture, Embedded Systems & Robotics

Computer Architecture

Data Warehousing

Introduction to Data Warehousing
Present Business Scenario, Operational and Informational Systems, What is a Data Warehouse? Applications of Data Warehouse, Problems with Data Warehousing

Data Warehouse Components, Processes & Architecture
Source Systems, Data Staging Area, Presentation Server, Data Marts, Operational Data Store (ODS), Metadata, Information Delivery, Basic Processes of a Data Warehouse

Data Warehouse Design

Extraction, Transformation, & Loading (ETL)
Data Extraction, Data Transformation, Data Loading, ETL Data Structures, ETL Tools: Build or Buy?

Online Analytical Processing (OLAP)
Need for OLAP, Features & Functions, ROLAP, MOLAP, HOLAP, & DOLAP, OLAP Implementation, OLAP Tools

Performance Enhancing Techniques
Partitioning, Aggregation, Materialization of Views, Bitmap Indexes

SQL Features for DW
CUBE Operator, Roll-up Operator Top-N Queries, Window Queries, Real-Time Data Warehousing

Advanced Databases

Multidimensional Indexing: kD tree, Quad Tree, Partitioned Hash Indexes, R-tree

Query Optimization: Heuristic optimization, Cost Based Optimization, Hybrid Approach, System-R Approach, View Materialization, Role of Metadata in Query Optimization

Distributed Database
Motivation & complexities, Homogeneous & Heterogeneous Distributed Databases, Distributed Data Storage, Data Fragmentation, Data Replication, Fragmentation & Replication, Data Transparency, Distributed Query Processing

Advanced Topics: NoSQL, Big Table, Big Data Management
Database Systems

Introduction to Database Systems

Objectives/Motivation, Evolution of Database Systems, Overview of a DBMS, Advantages of a DBMS, Database System Architecture

Data Modeling: Overview of Data Modeling, Entity-Relationship (ER) Modeling, Enhanced ER (EER) Modeling

Understanding Relational Model: Relational Model Concepts, Relation as a Mathematical Model, ER, EER to Relational model

Database Design through Functional Dependencies & Normalization: Functional Dependencies, Normal Forms: 1NF, 2NF, 3NF, BCNF, Criterion for Good Database Design, Multi-valued dependencies: 4NF

Query Language: Relational Algebra, SQL

Indexing: Indexing Structures, Primary & Secondary Indexes, Tree-structured Indexes, Hash-based Indexes, Bitmap Indexes


Software Engineering

Software Engineering Concepts and Methodologies; Software Requirements Analysis and Specification, Software Architecture, Detailed Design; Techniques of Design; Object Oriented Design, UML, Estimation; Software Project Planning, Integration & Validation; Software Quality Assurance; Software Maintenance; Automated Tools in Software Engineering.
Research Area 4: High Performance Computing and Distributed Systems

Parallel & High Performance Computing
- **General understanding**
  Shared Memory & Distributed Memory Systems, Concurrency & Multi-threaded systems and Multi-processor systems
- **Multicore-systems**
  Multi-core computing - homogeneous and heterogeneous, NUMA, and GPGPU computing;
- **Concurrency**
  Shared Data and Shared Memory Data Structures; Mutual Exclusion and solutions (for multi-processor systems)
- **High Performance Systems and Solutions; Scaling Models and Techniques; Development Models; High Performance Environments**
  Interconnects, Mapping, Scheduling, and Load Balancing.

Distributed Systems
- **Processes**
  Threads; Virtualization; Client-server structure; code migration;
- **Communication**
  RPC, Message & Stream Oriented Communication; Multicast communication;
- **Naming**
  Flat, structured and attribute based naming; DHT; DNS; LDAP;
- **Synchronization**
  Logical clocks; Mutual exclusion algorithms; Election Algorithms;
- **Caching, Consistency and Replication**
  Distributed Caches, Data centric consistency models; client-centric consistency models; replica management; consistency protocols;
- **Fault Tolerance**
  Failure models; Process resilience: agreement in faulty systems; failure detection; reliable client-server communication; reliable multicasting;
- **Distributed File Systems**
  Architecture; communication; naming; synchronization; consistency & replication; fault tolerance;
Research Area 5: Image Processing & Multimedia

Introduction, Multimedia Authoring and Multimedia Data Representations

Introduction to Multimedia What is Multimedia / Components of Multimedia / Multimedia and Hypermedia / World Wide Web (HTTP, HTML, XML, SMIL) / Overview of Multimedia Software Tools (for Music Sequencing and Notation, Digital Audio, Graphics and Image Editing, Video Editing, Animation, Multimedia Authoring

Multimedia Authoring and Tools Multimedia Authoring (Metaphors, Production, Presentation, Automatic Authoring) / Some Useful Editing and Authoring Tools / Virtual Reality Manipulation Language

Graphics and Image Data Representations Graphics/Image Data Types (1-Bit Images, 8-Bit Gray-Level Images, Image Data Types, 24-Bit Color Images, 8-Bit Color Images, Color Lookup Tables) / Popular File Formats (GIF, JPEG, PNG, TIFF, EXIF, Graphics Animation Files, PS, PDF, Windows WMF & BMP, PAINT, PICT, PPM)


Fundamental Concepts in Video Types of Video Signals, Analog Video (NTSC, PAL, SECAM) / Digital Video (Chroma Subsampling, CCIR Standards for Digital Video, High Definition TV)

Basics of Digital Audio Overview of Physics of sound / Digitization of Sound / Musical Instrument Digital Interface / Quantization and Transmission of Audio

Multimedia Data Compression


Lossy Compression Algorithms Distortion Measures / The Rate-Distortion Theory / Quantization / Uniform Scalar Quantization / Non-uniform Scalar Quantization / Vector Quantization / Transform Coding / Discrete Cosine Transform / Karhunen–Loeve Transform / Wavelet-Based Coding / Continuous Wavelet Transform / Discrete Wavelet Transform / Wavelet Packets / Embedded Zero-tree of Wavelet Coefficients / The Zerotree Data Structure / Successive Approximation Quantization / EZW Example / Set Partitioning in Hierarchical Trees
Image Compression Standards

Basic Video Compression Techniques and Video Coding Video Compression Based on Motion Compensation / Search for Motion Vectors (Sequential, 2D Logarithmic, and Hierarchical search) / Standards H.261 and H.263 / Overview of MPEG-1, 2, 4, 7, and 21

Audio Compression Techniques Basic Compression Techniques / G.726 ADPCM / MPEG Audio Compression / Psychoacoustics / MPEG Audio Coding

**Multimedia System Architecture**

Media and Streams, Multimedia System Architecture Media Types / Media Classification / Continuous Media / Discrete Media / Time-dependent Media / Time-independent media / Transmission Modes / Notion of Logical Data Unit

Storage Media for Multimedia Overview of magnetic storage / Optical Storage (CD-ROM, CD-WORM, CD-RW, DVD)


Multimedia communication systems Transport subsystems / QoS / Resource Management & the trends

Multimedia Database Management Systems Characteristics / Data Analysis / Data Structure / Operations

**Multimedia Application Architecture**


Overview of Multimedia User Interface Characteristics / User friendliness / User Interface through Video and Sound

Multimedia Application Architecture Multimedia Food Chain / Media Preparation / Media Composition / Media Integration / Media Communication / Media Consumption / Overview of Virtual Reality Systems

**Advanced Topics**

Synchronization Notion of synchronization / Presentation Requirements / Reference Model & Specification

Content-Based Retrieval in Digital Libraries How Should We Retrieve Images? / Current Image Search Systems / Relevance Feedback / Quantifying Results / Querying on Videos / Querying on Other Formats / Outlook for Content-Based Retrieval
Image Processing & Computer Vision

Introduction, Mathematical and Physical Background

Introduction Motivation / why is Computer Vision Difficult? / Image Representation and Image Analysis Tasks


Data Structures for Image Analysis Levels of Image Data Representation / Traditional Image Data Structures / Matrices / Chains / Topological Data Structures / Relational Structures / Hierarchical Data Structures / Pyramids / Quadtrees / Other Pyramidal Structures

Image Pre-processing, Segmentation and Mathematical Morphology


Segmentation Thresholding / Threshold Detection Methods / Optimal Thresholding / Multi-Spectral Thresholding / Edge Based Segmentation / Edge Image Thresholding / Edge Relaxation / Border Tracing / Border Detection as graph Searching / Border Detection as Dynamic Programming / Hough Transforms / Border Detection Using Border Location


**Shape Description, Object Recognition and Image Understanding**

Shape Representation and Description Region Identification / Contour-Based Shape Representation and Description / Chain Codes / Simple Geometric Border Representation / Fourier Transforms of Boundaries / Boundary Description using Segment Sequences / B-Spline Representation/Other Contour-Based Shape Description Approaches / Shape Invariants / Region-Based Shape Representation and Description / Simple Scalar Region Descriptors / Moments / Convex Hull / Graph Representation Based on Region Skeleton / Region Decomposition / Region Neighborhood Graphs / Shape Classes


Image Understanding Image Understanding Control Strategies / Parallel and Serial Processing Control / Hierarchical Control / Bottom-Up Control / Model- Based Control / Combined Control / Non-Hierarchical Control / RANSAC: Fitting via Random Sample Consensus / Point Distribution Models / Active Appearance Models / Pattern Recognition Methods in Image Understanding / Classification-Based Segmentation / Contextual Image Classification / Boosted Cascade of Classifiers for Rapid Object Detection / Scene Labeling and Constraint Propagation / Discrete Relaxation / Probabilistic Relaxation / Searching Interpretation Trees / Semantic Image Segmentation and Understanding / Semantic Region Growing / Genetic Image Interpretation / Hidden Markov Models / Coupled HMMs / Bayesian Belief Networks / Gaussian Mixture Models and Expectation-Maximization
3D-Vision and its uses


Use of 3D Vision Shape from X / Shape from Motion / Shape from Texture / Other Shape from X Techniques / Full 3D Objects / 3D Objects, Models, and Related Issues / Line Labeling / Volumetric Representation, Direct Measurements / Volumetric Modeling Strategies / Surface Modeling Strategies / Registering Surface Patches and their Fusion to get a Full 3D Model / 3D Model-Based Vision / General Considerations / Goad's Algorithm / Model-Based Recognition of Curved Objects from Intensity Images / Model-Based Recognition Based on Range Images / 2D View-Based Representations of a 3D Scene / Viewing Space / Multi-View Representations and Aspect Graphs / Geons as a 2D View-based Structural Representation / Visualizing 3D Real-World Scenes Using Stored Collections of 2D Views / 3D Reconstruction from an Unorganized Set of 2D Views

Advanced Topics

Advanced Techniques for Segmentation Mean Shift Segmentation / Active Contour Models - Snakes / Traditional Snakes and Balloons / Extensions / Gradient Vector Flow Snakes / Geometric Deformable Models - Level Sets and Geodesic Active Contours / Fuzzy Connectivity / Towards 3D Graph-Based Image Segmentation / Simultaneous Detection of Border Pairs / Sub-optimal Surface Detection / Graph Cut Segmentation / Optimal Single and Multiple Surface Segmentation

Texture Statistical Texture Description / Methods Based on Spatial Frequencies / Co-occurrence Matrices / Edge Frequency / Primitive Length (Run Length) / Laws' Texture Energy Measures / Fractal Texture Based Description / Multiscale Texture Description - Wavelet Domain Approaches / other Statistical Methods of Texture Description / Syntactic Texture Description Methods / Shape Chain Grammars / Graph Grammars / Primitive Grouping in Hierarchical Textures / Hybrid Texture Description methods / Texture Recognition Method Applications

Computer Graphics

Introduction and Basic Concepts

Basic Raster Graphics Algorithms for Drawing 2d Primitives Overview / Scan Converting Lines / Scan Converting Circles / Scan Converting Ellipses / Filling Rectangles / Filling Polygons / Filling Ellipse Arcs / Pattern Filling / Thick Primitives / Line Style and Pen Style / Clipping in a Raster World / Clipping Lines / Clipping Circles and Ellipses / Clipping Polygons / Generating Characters / SRGP_copyPixel / Antialiasing.


Transformations and Viewing in 3D


3D Representation and Modeling

Representing Curves and Surfaces Polygon Meshes / Parametric Cubic Curves / Parametric Bicubic Surfaces / Quadric Surfaces.


Adding Realism and Color


Illumination And Shading Illumination Modeling / Shading Models for Polygons / Surface Detail / Shadows / Transparency / Interobject Reflections / Physically Based Illumination Models / Extended Light Sources / Spectral Sampling / Improving the Camera Model / Global
Illumination Algorithms / Recursive Ray Tracing / Radiosity Methods / The Rendering Pipeline.

**Advanced Topics**


Advanced Geometric and Raster Algorithms Clipping / Scan-Converting Primitives / Antialiasing / The Special Problems of Text / Filling Algorithms / Making copyPixel Fast / The Shape Data Structure and Shape Algebra / Managing Windows with bitBlt / Page Description Languages /

Advanced Modeling Techniques Extensions of Previous Techniques / Procedural Models / Fractal Models / Grammar-Based Models / Particle Systems / Volume Rendering / Physically Based Modeling / Special Models for Natural and Synthetic Objects / Automating Object Placement.
Research Area 6: Networking and Mobile Computing

Computer Networks:
This course introduces concepts, terminologies and techniques used in computer networking. The objective of this course is to introduce students to functions of different layers, protocols and different components of a modern day computer network. Example network covered in this course is the Internet.

**Introduction:** Uses of Computer Networks, Network Hardware: The Network Edge, Network Core, Access Networks; ISPs and Internet Backbones, Delay and Loss in Packet Switched Networks, Network Software: Protocol Hierarchies, and their Service Models, Reference Models (OSI, TCP/IP)

**Application Layer:** Hypertext Transfer Protocol, HTTP Message Format, Cookies, Conditional GET. File Transfer Protocol: FTP, TFTP. Mail Transfer Protocols (SMTP, POP3, MIME), Domain Name Systems (DNS), P2P File Sharing

**Transport Layer:** Multiplexing, Demultiplexing, UDP, Principles of Reliable Data Transfer (Go-Back-N, and Selective Repeat). Introduction to Socket Programming; TCP, UDP, Simple Client Server Application;

**TCP:** RTT Estimation and Timeout, TCP Flow Control; TCP Error Control and Congestion Control, SCTP protocol.

**Network Layer:** Virtual Circuits and Datagram Networks, Inside a Router, Forwarding and Addressing in the Internet. IPv4 Addressing, IPv6 Addressing, Routing Algorithms: Shortest Path, Flooding, Link State, Distance Vector, and Hierarchical Routing, Routing in the Internet: RIP, OSPF, Border Gateway Protocol (BGP), and Multicast Routing Protocols: DVMRP, MOSPF, PIM-SM, PIM-DM.

**Data Link Layer:** Services, Error Detection and Correction Techniques (Parity Checks, Checksums, CRC); Multiple Access Protocol: TDM, FDM, Slotted ALOHA, Pure ALOHA, CSMA, CSMA/CD, Local Area Networks, Ethernet, Point to Point Protocol. Link Virtualization: Asynchronous Transfer Mode (ATM), Multi Protocol Label Switching (MPLS), Link Layer Addressing: MAC Addresses, ARP, RARP, DHCP, Interconnections: Hubs, Bridges, and Switches.

**Physical layer:** Bandwidth limited signals, Fourier analysis, Guided and Unguided media, Signal encoding, Maximum data rate, etc.

Mobile Computing
Introduction to Mobile Communications and Computing, Introduction to the concepts of mobility and roaming, Types of mobility, Types of Mobile Networking environments: Personal, Local, Metropolitan Area and Wide Area, Cellular forms of Mobility: 2G, 2.5 G, 3 G, 4 G and evolving directions towards so-called 5 G, Medium Access Control for Wireless Protocols, Mobile Network Layer, Mobile Transport Layer, Data Dissemination, Mobile Ad

**Network Security**


**Advance Topics in Computer Networks**


**Internetworking**: Design Principles, IP Design, Inter-domain Routing vs. Inter-domain Routing, Challenges in Internet Routing, Security challenges/Issues and solutions for Inter-domain Routing, Adaptive Routing, Multipath and QoS Routing, Scalable & Reliable Application layer Multicast Routing, Multi Protocol label Switching (MPLS) and Generalized-MPLS

Research Area 7: Algorithms & Theoretical Computer Science

Data Structures and Algorithms
Algorithm analysis and asymptotic notation. Sorting and searching algorithms and applications. Design, implementation and applications of data structures including stacks, queues, priority queues, linked lists, hash table, heap, binary search tree, balanced binary search tree. Algorithm design techniques like Divide and Conquer, Greedy Approach, Dynamic Programming, Backtracking, Branch & Bound for designing algorithms. P, NP, NP Completeness. Theory of Computations- Finite automata and regular languages-equivalences, closure properties; Context free languages and push down automata-equivalences, closure properties; concepts in parsing; Turing machines; Computability and decidability-universal Turing Machine; recursive functions; church-Turing hypothesis; complexity classes - P, NP, reducibility and NP completeness.

Discrete Structures for Computer Science
Sets & operation on sets; relations & equivalence relations; number theory; weak & strong form of mathematical induction; principle of inclusion & exclusion, pigeonhole principle; recurrence relations & generating functions; digraphs & graphs, graph isomorphism & subgraphs, spanning trees, Euler & Hamiltonian graphs, planar graphs, chromatic numbers & graph coloring; groups.

Design & Analysis of Algorithms-
BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCES, PILANI

Department of Electrical and Electronics/Instrumentation Engineering

Thrust/ Research Areas for Ph.D

INSTRUMENTATION & CONTROL:


COMMUNICATION ENGINEERING, NETWORKS

RF, MICROWAVE, ANTENNA DESIGN & WIRELESS SYSTEMS:


POWER SYSTEMS & ELECTRICAL ENGINEERING, RENEWABLE ENERGY, SMART GRIDS:


POWER ELECTRONICS AND DRIVES:


EMBEDDED SYSTEMS:


MICRO/ NANO ELECTRONICS


ELECTRONIC MATERIALS, DEVICES, AND TECHNOLOGY:

Materials And Devices For Electronic, Photonic, Bio-Electronic And MEMS Applications: Amorphous And Crystalline Silicon, Compound Semiconductors, Thin Films, Ferroelectric And Piezo-Electric; Smart Materials, Development Of Novel Device Structures And Manufacturing Methods, Physics And Modeling Of Devices, Device And Material Characterization, Physics And Modeling Of semiconductor Devices, Optoelectronics and Optical Communication, Detectors, Semiconductor Lasers, IC Fabrication Technology issues, BJT, MOSFET process flow, CMOS and NMOS technologies, 3-dimensional integrated circuits, Submicron fabrication issues, Emerging Nanoelectronics, Spintronics technology, MEMS fabrication, Semiconductor and dielectric material research for IC technology, Mixed Signal and RF technology, Silicon on Insulator technology, Recent trends and Advanced technologies.

DIGITAL SIGNAL PROCESSING:

| Chemical Engineering | 1. **Transport Phenomena & Separation Processes**  
Fluid mechanics, Computational fluid dynamics, Fluid-Structure interactions, Computational transport phenomena, Multiphase flow, Heat, Mass and Momentum transfer phenomena, Process and mechanical design of heat and mass transfer equipments, Size reduction, Classical and Advanced Separation processes, Cryogenics, Fluidization Engineering, Reactive transport in porous media, Colloidal and interfacial science.  
| 2. **Chemical Reaction Engineering & Thermodynamics**  
Kinetics of single and multiple reactions, Ideal and non-ideal reactor operations and its design, Microreactors, Heterogeneous reactions, Phase equilibria, Thermodynamic properties estimation for ideal and nonideal fluids, Applied Thermodynamics, Statistical thermodynamics, Supercritical fluids.  
| 3. **Material Science and Engineering**  
Material structures (amorphous&crystalline), Phase diagrams, Material Characterization, Failure analysis and Non-destructive testing, Metals and super alloys, Ceramics, Polymers and Composites, Semi and Super conductors, Biomaterials, Pulp and Paper, Materials for renewable energy, Development of foams, Corrosion and degradation of materials, Nanotechnology, Biomedical engineering.  
| 4. **Environmental Engineering**  
Water analysis, Classical and advanced water treatment, Air pollution control and modelling, Solid waste management and treatment, Health-Safety-Environment (OSHA, HAZOP, Risk analysis), Process Plant Safety, Environmental management systems, Life cycle assessment (LCA), Bioremediation, Nanotoxicology.  
| 5. **Energy and Process System Engineering**  
| 6. **Petroleum and Petrochemical Engineering**  
Refinery operation & design, Crude & Product characterization, Petrochemicals, Energy from fossil fuel, Reservoir engineering and Oil recovery, Modelling and Simulation in petroleum refining, Petroleum economics.  
| 7. **Biochemical Engineering**  
Cell culture technology, Industrial biotechnology, Environmental biotechnology, Pharmaceutical & Food Biotechnology, Biogeochemical interactions, Biofuels, Fermentation, Bioprocess engineering, Tissue Engineering, Biomaterials, Biometallurgy, Biokinetics and bioreactors. |
Ph.D. Qualifying Examination Syllabus

Broad Research areas have been classified in **EIGHT** subgroups. The subareas identified and the corresponding courses are enlisted below:

1. **DESIGN ENGINEERING**
   - Dynamics and Vibrations
   - Theory of Elasticity and Plasticity
   - Fatigue, Creep and Fracture
   - Product Design
   - Tribology
   - MEMS
     - Biomechanics

2. **Computer Aided Engineering**
   - Finite Element methods
   - CAD
   - Robotics
   - Mechatronics
   - Design Optimization

3. **THERMAL ENGINEERING**
   - Conductive and Radiative heat Transfer
   - Convective Heat Transfer
   - Refrigeration and Air-conditioning
   - Renewable energy
   - Internal Combustions engines
   - Advanced Thermodynamics and Combustion

4. **FLUID ENGINEERING**
   - Compressible Flows
   - Viscous Flows (Advanced Incompressible Flows)
   - Fluid Power Engineering
   - Turbulence
   - Computational Fluid Dynamics (CFD)
   - Turbo machines
     - Microfluidics
     - Bio-Medical flows specific to cardiovascular disease
     - Fluidization engineering and circulating fluidized bed (CFB)

5. **MANUFACTURING ENGINEERING**
   - Machining processes (Techniques)
   - Advanced Metal Forming
   - Design of Machine Tools
   - Casting and Welding
· Unconventional (Advanced) Machining Processes
· Tool design

6. INDUSTRIAL ENGINEERING AND OPERATIONAL RESEARCH
· Operations Research
· Modeling and Simulation
· Supply Chain Management
· Organizational Management

7. MANUFACTURING MANAGEMENT
· Quality Control, Assurance and Reliability
· Total Quality Management (TQM)
· Computer Integrated Manufacturing (CIM)
· Flexible Manufacturing System (FMS)
· Lean Manufacturing

8. MATERIALS
· Material Science and Engineering
· Composite Materials
· Nano sciences and Nano materials
· Polymeric Materials
· Physical Metallurgy
· Material testing
· Biomaterials

- The student can opt for one area consisting of three courses out of number of courses specified under that sub-area according to his research topic or Master’s Degree Specialization
- One allied area consisting of three courses out of number of courses specified under that sub-area that may be useful for him during his research or other three courses can be from any of the subareas depending upon its significance in candidate’s research.
- In case of Interdisciplinary Research, if the candidate needs to take the courses of the other departments, he can select maximum of three courses from the sub areas of the concerned departments.

The proposal will facilitate intra and interdisciplinary research.

The course content can be referred from Institute Bulletin wherever available while remaining can be decided by the mentor in consultation with the candidate and DRC.
Macroeconomics

Content A

Systems of national accounts; input-output systems; flow of fund systems; monetary circulation and exchange; basic model of income determination; classical macroeconomic models; obstacles of full employment; Keynes model, derivation of IS-LM functions; three sector model; four sector model; inflation and Phillips curve; real business cycles and new Keynesian economics; monetary policy, fiscal stabilization policy; consumption hypothesis; absolute income hypothesis, permanent income hypothesis, life-cycle income hypothesis, relative income hypothesis, investment models; money supply and money demand.

Content B

Overview of the financial system, interest rate and their role in valuation, fluctuation in interest rate, risk and term structure of interest rate, rational expectation and efficient market hypothesis, central banking and the conduct of monetary policy, money supply and credit creation, monetary transmission mechanisms, fundamentals of financial institutions, banking and management of financial institutions, commercial banking industry, risk management in financial institutions, credit risk, analysis of various financial and economic crisis.

Microeconomics and Industrial Economics

Content A

Consumer behavior; production function and linear programming applications, derivation of cost and supply functions, markets and market structures. Commodity pricing under imperfect market structures, factor pricing, multimarket equilibrium, optimization over time, welfare optimization, game theory applications, industrial organization.

Content B

Methodological and theoretical introduction into the tools, methods and approaches used in industrial economics; the firm and the agency relations within business organizations; concentration, mergers and entry barriers; review of game theoretic concepts; nature of markets; imperfect competition in static and dynamic settings; theoretical and empirical studies of collusion and cartels, monopolistic behaviour, vertical integration and determinants of market structure.; industrial policy and efficiency analysis, including government regulation and natural monopolies reforms with examples and applications. Market structure and strategic interaction; oligopolistic behaviour models; entry costs, market structure and welfare; pricing tactics: discriminatory pricing; non-price competition, product-differentiation and advertising ; marketing tactics: bundling, upgrading and dealership; vertical restraints; research and development; empirical studies on structure-conduct-performance relationship; empirical studies on market performance; competition policy and regulation.
Public Finance and Policy.

Content A

Role of Government in modern economy, Theory of Public good and public choice; public goods and externalities, equity in distribution, Public Expenditure and Macro-economy: Determining optimal size of government, financing of public expenditure, debt versus tax financing, impact of public expenditure on the level and composition of output and employment, Government budget and cost benefit analysis, Taxation; Direct and Indirect taxes, efficiency and equity, tax incidence, models of taxation incidence, theory of optimal taxation, recent developments in theory of taxation, evolution of tax structures, tax evasion and avoidance, designing of modern tax system, reforms in direct and indirect taxes, value added tax, fiscal federalism, designing optimal government expenditure policy; Fiscal Policy Issues: Budget deficit and public debt, interdependence of fiscal and monetary policies, theory of inter-governmental transfers, theory and policy of subsidies, theory of fiscal federalism, issues of equity and efficiency, role of planning and finance commission, goods and services tax in India, new direct tax code, role of central and state FRBM's.

Content B

Introduction to of economic analysis; economic tools in valuing outcomes; measuring outcomes in policies and programme; policy making; the market and the public policy, policy framework and regulation, market and government issues, distribution and policy analysis; applications in tax policies, welfare policies, government policies relating to contracting, health, education, labour and employment, energy policy, competition policy, gender, rural-urban development, food security, climate change, infrastructure policy, financial and trade policy. Theoretical and empirical aspects of poverty, inequality and unemployment analysis; Public Policy for Development, Micro finance: Theoretical Aspects and Impact Evaluation, Growth theory models and their empirical applications, Theory of Human Capital and Educational Economics: Their relationship with economic growth.

International Economics

Content A

The international economy; early trade theories; comparative advantage model; neo-classical trade theories; gains from trade; offer curves, terms of trade; Edge-worth box, factor endowments and the Heckscher-Ohlin model; alternative models of trade and intra-industry trade; the imitation-lag hypothesis; product cycle theory; international trade and economic growth; international trade policy; tariff, non-tariff trade barriers, economic integration, international trade and economic development, Basic gravity modeling, New-new trade theories (Firm level trade).
Content B

International factor movements; foreign direct investment and multinational corporations; protection; GATT & WTO; the balance of payments accounts; balance of payments equilibrium; economic policy in the open economy, balance of payment accounting, foreign exchange markets and exchange rates, exchange rate determination, open economy macroeconomics; income and price adjustment mechanisms, adjustment policies.


Content A

Specification of simple linear regression model, least square method of estimation, classical assumptions, general and confidence approach to hypothesis testing. Specification of Models; estimation of single equation economic models and related problems; Auto -correlation, multicollinearity and hetroscedasticity, forecasting and verification; estimation methods and problems in simultaneous equation systems.

Content B

Multiple regression analysis; analysis of generalized linear and nonlinear models; instrumental variables; maximum likelihood, generalized method of moments (GMM), and two step estimation methods; simultaneous equation models; time series processes; identification and estimation of time series models; techniques for assessing model fit; forecasting; time series analysis and models of expectations; univariate time series analysis, stationary vs. non-stationary series; ARIMA, GARCH, VAR, cointegration, granger causality, error correction and limited dependent variable models; auto regressive distributed lagged variable models multivariate time series analysis; dynamic models; analysis of panel data, balanced and unbalanced panel data, mixed, fixed and random effect models.

Corporate Finance

Content A

Concepts and techniques of financial management decision; valuation of a firm's stock; investment in assets and required returns; financing and dividend policies, working capital management, management of cash, management of accounts receivable; inventory management, short and intermediate term financing, financial analysis, financial ratio analysis, funds analysis and financial forecasting, operating and financial leverages. Market for corporate control, Incentives and compensation, Corporate governance.
Content B

concepts in valuation - time value of money; NPV, IRR, project feasibility, budgeting, long term investment decisions, long term financing decisions (LT & ST), capital structure, risk analysis; principles of corporate taxation, income tax, capital gains tax, tax laws and provisions.

**Investment Analysis and Management**

Content A

Introduction to investment and securities; profile of financial assets; new issue market or primary market, initial public offerings (IPO); secondary market; trading and settlement procedures; listing requirements; framework of risk & return; fundamental analysis-economy, industry; company analysis; stock evaluation models; multiple holding period and multiple growth rate; bond analysis and bond management strategies; mutual funds; technical analysis; efficient market theory; portfolio management; Markowitz model; Sharpe’s Single Index model; capital asset pricing model; financial derivatives options & futures. Arbitrage pricing models, Stochastic discount factor methodology, Behavioral finance.

Content B

Value maximization, stakeholder theory, and corporate objective function: value creation – ways and means, business analysis: The techniques of strategy and competitive analysis, value chain analysis for competitive advantages, business valuation – approaches and methods, the dark side of valuation: strategic investment decisions; SEBI Regulations w r t corporate governance; insider trading; fraudulent and unfair trade practices, and substantial acquisitions & takeovers, Management of banks, Financial Services, Insurance companies; Asset Liability management in banks, Capital Adequacy Norms, Basle regulations on risk capital, Actuarial Science.

**Financial Economics and Financial Engineering.**

Content A

Functions and operations of capital market, analysis of consumption-investment decisions of investors, diversification and portfolio selection, valuation theory and equilibrium pricing of risky assets, theory of efficient markets and investment and financing decisions of the firm. Expected utility theory; stochastic dominance; portfolio frontiers; mutual fund separation; asset pricing model; arbitrage pricing theory; Arrow-Debreu theory; dynamic spanning; options; rational expectations; financial signaling.

Content B

Introduction; Review of Markets, Players, and Conventions; Cash Flow Engineering with Forward Contracts; Engineering Simple Interest Rate Derivatives; Swap Engineering; Report Market Strategies; Dynamic Replication Methods and Synthetics; Mechanics of Options;
Options Engineering with Applications; Pricing Tools; Applications of Fundamental Theorem of Finance; Fixed Income Engineering; Tools for Volatility Engineering: Volatility Swaps and Volatility Trading; Engineering of Equity Instruments: Pricing and Replication, computational methods such as Monte Carlo Simulation.
Department of Humanities and Social Sciences – Research Areas

Cultural Studies

Sub area 1
Media and Communication

Areas of Research:
Advertising Discourse, Political Discourse in Media, Contemporary practice of Journalism, Social Media Network V/S Traditional Media, Tourism communication, Media Literacy, Print V/S Digital, Media Ethics, Computer-Mediated Communication, Technology Enabled Education and Communication, Technology Integration and Analysis, Communication Theories, Organizational Communication, Language and Communication, New Media Study;

Reading List

- Media Ethics, Philips Patterson and Lee Wilkins, Tata Mc Graw Hill, 6th Ed, 2010
- Practicing Video Journalism, Viven Morgan, Routledge 1st Ed ,2010
- The Discourse of Advertising, Guy Cook, 2nd Ed, Routledge
- Language and Media, Allan Durant and Marina Lambrou, 1st ed ,2010

Sub Area 2
Film:

Areas of Research:
Essentials of Cinema, Understanding of film as a text and context, Basics of film language, Understanding of the evolution of film as a language and understanding of different film schools, Similarities and dissimilarities with other art forms, World cinema, renowned trendsetting films, Major Auteurs,
Film Theories.

Reading List

- Stam, Robert. Film Theory: An Introduction.
• The Oxford Guide to Film Studies. W. John Hill and Pamela Church Gibson, Oxford University Press, 1998

**Sub area 3**

**Theatre**

**Areas of Research:**
Indian classical theatre with special reference to Natyashstra, Development and tradition of Indian traditional/folk theatre with special focus on musical narratives of north-india, Post-independence Indian modern theatre and the role of National School of Drama, Post-independence stage design in Indian contemporary theatre, Site-specific, site-generic, site-based performance arts. Theatre and its allied arts; lighting and scenography.

**Reading List**
• N.C. Jain *Indian Theatre*, Vikash Publishing House, New Delhi, 1992
• Rangdarshan (In Hindi); Nemichandra Jain; Jain Books, 20084.
• Nemichandra Jain : *Asides, Themes in Contemporary Indian Theatre*, National School of Drama, 2003
• National School of Drama, *Rang Yatra: Twenty-five years of the National School of Drama Repertory Company.*, Published by National School of Drama, 1992

**English Language Linguistics and Literature**

**Sub area 1**

ESP and ELT
• *Evans D.T. and John, St Jo Maggie*, Developments in English for Specific Purposes: A Multidisciplinary Approach, Cambridge University Press(Paperback)
• *Algeo John*, The Origins and Development of the English Language. Sixth edition. Wadsworth, USA. 2010

**Sub area 2**

Linguistics
• *Akmajian A*, et al. Linguistics: An Introduction to Language and Communication. New Delhi:

**Sub area 3**

Indian Literatures
- Meenakshi Mukherjee, ed. Early Novels in India. New Delhi: Sahitya Akademi.

**Sub area 4**

American Literature

**Sub area 5**

Post Colonial Literature
- Homi Bhabha, The Location of Culture. London: Routledge, 1994

**Sub area 6**

Literary Criticism and Ecocriticism
- Rivkin Julie and Michael Ryan, Literary Theory: An Anthology
- Julian Wolfreys, Ruth Robbins and Kenneth Womack, Key Concepts in Literary Theory
- The Cambridge History of Literary Criticism (All Volumes)
- Donelle Nicole Dreese, Creating Self and Place in Environmental and American Indian Literatures
- Greg Garrard, The Oxford Handbook of Ecocriticism
- Peter Barry, Beginning Theory: An Introduction to Literary and Cultural Theory
Ken Hiltner, Ecocriticism: The Essential Reader
Richard Kerridge and Neil Sammells, Writing The Environment: Ecocriticism and Literature
Axel Goodbody, Ecocritical Theory: New European Approaches
Patrick D. Murphy, Ecocritical Explorations in Literary and Cultural Studies: Fences, Boundaries and Fields

Sub area 7
Gender Studies
- Edited by Althea Prince, Susan SilvaVayne and Christian Vernon, Feminisms and Womanisms: A Women’s Studies Reader
- Patrick Keilty and Rebecca Dean, Feminist and Queer Information Studies Reader
- The Polity Reader in Gender Studies

Sub area 8
Religion and spirituality
- Zohar and Marshall, Spiritual Intelligence, The ultimate Intelligence, Bloomsbury Publications 2001
- Zohar and Marshall, Spiritual Capital: Wealth we can live by, Berrett Koehler, USA
- Brian Draper, Spiritual Intelligence: A new way of being

Sub area 9
Applied Linguistics

Sub area 10
British Literature
- Emile Legouis, History of English Literature, OUP
- A.S Collins, English Literature of the 20th Century
- David Daichies, A Critical history of English Literature, Supernova Publishers
- Aristotle, Poetics, Kalyan Publishers

Sub area 11
Dalit studies

- **Morton Klass**, *Caste: The Emergence of the South Asian Social System*, Philadelphia: ISHI, 1980
- **Nicholas B. Dirks**, “Castes of Mind: Colonialism and the Making of Modern India” New Delhi: Permanent Black, 2002
- **Sharmilla Rege**, *Writing Caste / Writing Gender Reading Dalit Women’s Testimonies*. New Delhi: Zubaan, 2006
- **G. Alosyius**, Dalit Subaltern Emergence in Religio-Cultural Subjectivity
- **Iyothee Thassar**, *Emancipatory Buddhism*, New Delhi: Critical Quest, 2004

Sub area 12
Creative writing

- **David Morley**, *The Cambridge Introduction to Creative Writing*. New Delhi: CUP.
- **Wendy Bishop and David Starkey**, *Keywords in Creative Writing*. Logan: Utah State UP, 2006.

Sub area 13
Rhetorics

- **Dam L. Pierce**, Rhetorical Criticism and Theory for Communication Professional, Paperback. 2003

Sub area 14
Feminism

- **Sylvia Plath**, *The Bell Jar*
- **Simone de Beauvoir**, The Second Sex
- **Zoya Hasan**, Forging Identities: Gender, Communities, and the State
- **Carol Chapnick Mukhopadhyay and Susan Seymour**, *Women, Education, and Family Structure in India*
• Mandakranta Bose, Faces of the Feminine in Ancient, Medieval, and Modern India
• Judith Evans, Feminist Theory Today: An Introduction to Second-Wave Feminism

**Philosophy, Indian Philosophy and Ethics**

**Areas of Research: Ethics**
History and Content of Philosophical Perspectives – Ethical, Logical, Epistemological and Metaphysical; Continental Rationalism; British Empiricism; Normative Ethics and Meta Ethics; Aristotle on Virtues and Moral Wellbeing; John Stuart Mill on Utilitarianism; David Hume on Sympathy; Immanuel Kant on Categorical Imperative; Ethical Self in Existentialism; Ethical Issues in Professions: Whistle Blowing, Women and Family Issues, Corporate Social Responsibility, Marketing Ethics and Advertising Ethics, Engineers and Public Interest, Internet and Society, Privacy on the Internet.

**Areas of Research: Indian Philosophy**
Introduction to various Indian philosophical systems, Vedas and upanisads, Atman and brahman, Vedanta system: non-dualism of Sankara, Sankara on the absolute, self, and world, Ramanuja: qualified non-dualism and self, Atomism of Vaisesika, Nyaya: sources of knowledge, causation, Samkhya: purusa and prakrti, Yoga: chitta and its vrittities, astanga yoga, Buddhism: four noble truths, doctrine of dependent of origination, nirvana, Jainism: anekantavada, syadavada, kaivalya

**Reading List**
- Grayling, A.C., Philosophy: A Guide through the Subject, Oxford University Press, 1995
- Rowan, John, and Zinaich, Jr., Ethics for the Professions, Wadsworth, 2003
- Sharma, C.D., A Critical Survey of Indian Philosophy
- Singer, Peter, A Companion to Ethics, Oxford: Blackwell Publishers, 1993
- Thilly, F., A History of Philosophy, Central Book Depot, Allahabad, 1984

**Education:**
Areas of Research:
Communicating climate change; Relating formal and informal learning; Engaging learners with scientific practices; Teaching and learning in informal setting; Teaching strategies and teacher PD; Adult education; Leadership; Motivation; Classroom Management; Curriculum studies; Qualitative research; Quantitative research; Technology and education; International and comparative education; Teaching and teacher education; Educational psychology

Reading List

- Dynamic classroom by Bruce M. Mitchell; Kendall Hunt Publication Co. ISBN – 10 – 0840362617

History and Politics:
Areas of Research:
Transitional politics; Social movements; International relations; Comparative politics; Urban politics; International relative theory; Behavioral politics; public opinion; Political communication; International organization & law; International relations theory; History of science; Urban environmental history; History of economic thought; History of technology and science; History of engineering and technology; History of life sciences, science and fascism.

Reading List

- India's Struggle for Independence by Bipan Chandra, Mridula Mukherjee August 1st 2012 by Penguin Global
- India: A History by John Keay Paperback, 608 pages Published April 10th 2001 by Grove Press
- International Relations Theory; by Colin Wright.
- International Encyclopedia of Social & Behavioral Sciences; by N.J. Snelser, James Wright, P.B. Baltes

Psychology
Areas of Research:


Public Administration
Areas of Research:

Reading List
- Civil Service Administration by C.P.Bhardwaj;
- Personnel Administration by S. L. Goel;
- Local Self Government in India by M.P.Sharma;
- Public Administration in India by Padma Ramachandran;
- Indian Administration by Shriram Maheshwari

Development Studies:
Development studies is an inter-disciplinary subject which aims to provide an understanding of development process through a study of concepts, theories and approaches to development.

Areas of Research:

Reading List
- Baviskar, BS and George Mathew.2009. Inclusion and Exclusion in Local Governance: Field studies from Rural India. New Delhi: SAGE.

Public health:
Areas of Research
Key concepts, theories and history of public health; India - history of public health from colonial era to post-independence; key developments in public health since 1947; achievements, failures, challenges; global health since the 20th century

Environmental Studies:
Areas of Research:
Environment in history, from the ancient times to the present- environmental challenges since industrialization and urbanization- environment as a multidisciplinary issue- science, technology- development and environment: economy, society, politics and environment.

Reading List:
• Mahesh Rangarajan & K. Sivaramakrishnan. (ed.) 2013. India’s Environmental History: A Reader, 2 Vols. Permanent Black.
Sociology
Areas of Research:

Reading List:

- Sociology – Anthony Giddens
- Sociology – Haralambos and Holborn
- Sociological Thinkers – R.K.Mukherjee
- Sociological Thought – Francis Abraham and Morgan
- Social Stratification – Dipankar Gupta
- Handbook of Indian Sociology – Veena Das
- Family, Marriage and Kinship in India – Patricia Uberoi
- Caste in Modern India and other essays – M.N.Srinivas
- Rural Sociology – Doshi and Jain
- Social Research Methods – Clive Seal