Course Content of
MIS

Academy of Scientific & Innovative Research (AcSIR)

Mathematical and Information Sciences (AcSIR:MIS)

Ph D Programme: 2012

Contents

CSIR-CMMACS (Mathematical and Information Science Courses)

Course No.	Course Title	L	T	P	C
Common Core					
MIS (C-MMACS): 1-101	Research Methodology	1	1	0	2
MIS (C-MMACS): 4-102	CSIR-800 Societal Program	0	0	8	4
MIS (C-MMACS): 3-103	Advanced Self Study	0	2	4	4
MIS (C-MMACS): 4-104	Project Proposal and Review Article (one each of 2 credit)	0	1	6	4
Electives					
MIS (C-MMACS): 3-105	Reasoning and Quantitative Thinking	2	1	0	3
MIS (C-MMACS): 2-106	Principles and Techniques of Mathematical Modelling	3	0	0	3
MIS (C-MMACS): 3-107	Advanced Numerical Techniques	2	1	0	3
MIS (C-MMACS): 3-108	High Performance Scientific Computing	2	1	0	3
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MIS (C-MMACS): 3-110	Introduction to Non-linear Dynamics	2	1	0	3
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Brief Description of Courses at CSIR-CMMACS (Course Level-Wise)

MIS (CMMACS):1 - 101	**Research Methodology** **Course Coordinator – Dr. P Goswami**	**1-1-0-2**

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

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

MIS (CMMACS):4 -102	**CSIR 800 Societal Program** **Course Coordinator: Dr E Desa**	**0-0-8-4**

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme, which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory.

MIS (CMMACS):3 -103	**Advanced Self Study** **Course Coordinator: PhD Guide**	**0-2-4-4**

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

MIS (CMMACS):4 - 104	**Project Proposal and Review Article (one each of 2 credits)** **Course Coordinator: PhD Guide**	**0-1-6-4**

One subject proposals to be prepared before comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc and review article on a special topic in the area of research. (2 credits each)

MIS (CMMACS): 3-105	**Reasoning and Quantitative Thinking** **Course Coordinator - Prof. V K Gaur**	**2-1-0-3**

Reasoning[1]-Philosophy[2]-Science[3]: the eternal cycle towards framing significant questions and validating knowledge through examples[4]

Analysis of valid and invalid reasoning through examples such as syllogism[5]

Enquiry in the method (?) of establishing knowledge(science) through analysis of Aristotle's Inductive-deductive schema and its continual refinement through the ages to Popper's falsification criteria.

An understanding of the validity and value of Induction through analysis of Mathematical Induction and exploration of 'inductive processes' discernible in the road to some key scientific discoveries

An exploration of the development chain of some key concepts such as the definition of a 'number'- from Peano to Frege - as an example of relentless march towards bridging the chasm between consistency and completeness. Self study to look for and explain other examples[6]

Symbolic Logic: its journey from Leibnitz's prescient programme through a long refinement by Frege, Cantor, Turing and others

The explosive illumination of science coupled to mathematics: quantitative verification, prediction, engineering and systems design, algorithmic explorations.

Notes

1. Deduction from plausible ideas or propositions
2. Scrutiny of methods, procedures bases and criteria for their logical validity as well as of the way we use concepts
3. Empirically validated knowledge that remains tentative till supplanted by new paradigms
4. This cycle will be exemplified by analyses of the origin of ideas and hypotheses, and their evolutionary journey towards refinement, and replacement by revolutionary new Ideas: The Phlogiston theory, Newton's constant Universe, the Ether theory, the quantum theory etc.
5. These will be worked examples and include exercise in the formulation of valid and invalid syllogistic reasoning.
6. This approach will be followed throughout

MIS (CMMACS): 2-106	**Principles and Techniques of Mathematical Modelling: Dr. V Y Mudkavi**	**3-0-0-3**

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

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

Recommended Books

1. Bender, E. A. *An Introduction to Mathematical Modeling.* John Wiley and Sons. 1978.
2. Goldreich, P., Mahajan, S., Phinney, S. *Order-of-Magnitute Physics: Understanding the Wold with Dimensional Analysis, Educated Guesswork, and White Lies.* 1999.
3. Nearing, J. *Mathematical Tools for Physics.* www.physics.miami.edu/nearing/mathmethods/. 2003.
4. Koonin, S. E. *Computational Physics.* Benjamin/Cummings. 1986.
5. Golub, G. H., Ortega, J. M. *Scientific Computing and Differential Equations: An Introduction to Numerical Methods.* Academic Press. 1992.

6. Aris, R. *Mathematical Modelling Techniques.* Dover. 1995.
7. Abraham, R. H., Shaw, C. D. *Dynamics: The Geometry of Behavior.* Addison-Wesley. 1992.
8. Aris, R. *Vectors, Tensors and the Basic Equations of Fluid Mechanics.* Dover. 1962.

MIS (CMMACS): 3-107	Advanced Numerical Techniques Course Coordinator - Mr V Senthilkumar	2-1-0-3

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

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

Higher Order Methods: Spectral Method, Pesudospectral Method

Recommended Books:

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

MIS (CMMACS): 3-108	High Performance Scientific Computing Coordinator - Dr G K Patra	2-1-0-3

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

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

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

Recommended Books

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

MIS (CMMACS): 2-109	Mathematical Modeling: Principles and Application Course Coordinator: Dr R N Singh	2-1-0-3

Steady field and potentials (Laplace, Poisson and biharmonic equations)
Gravitational potential, continuous distribution of mass; Electrostatics, charge free, point, surface and volume chargers; electrostatics, point, surface and volume sources; hydrostatics, Bernoulli equation, Stokes flow, Couette flow, Poiseuille Flow; Steady heat flow, point and distribute sources, stratified media; examples for earth system science using analytical and numerical methods.

Diffusion of fields (Heat equation)
Transient heat conduction, point, surface and volume sources, phase change, stratified media; Electromagnetic diffusion, sources, stratified media; pore pressure diffusion, sources, stratified media; stress diffusion in elastic/viscous media; Chemical diffusion, sources and chemical reactions; examples from earth system science using analytical and numerical methods.
Waves fields (wave equation)
Electromagnetic harmonic waves, stratified media, waveguides, antenna; transient electromagnetic waves, sources, stratified media; harmonic elastic waves, body and surface waves, sources and free oscillations; harmonic waves in fluid media, sources, stratification; transient waves, sources in continuous media; examples from earth system science using analytical and numerical methods.
Nonlinear and inverse problems
Reaction diffusion equation, travelling wave solution; population growth and dispersion; filtration equation; solitary waves; barotropic and baroclinic instabilities; parameterized climate models; parameter estimation in underdetermined systems, regularization; examples from earth system science using analytical and numerical methods.

Recommended Books
Aster, R., Borchers, B. and Thurber,C. Parameter Estimation and Inverse Problems, Elsevier, 2005.
Holton, J. Introduction to dynamics meteorology, Elsevier 2004
Jaupart C and Mareschal, J.-C. Heat generation and transport in the earth, 2011, CUP
Marshal and Plumb, Atmosphere, ocean and climate dynamics, Elsevier, 2008
Parker, DF, Fields Flows and Waves, An introduction to continuum models, Springer, 2003
Plawsky, J. Transport phenomena fundamentals, CRC press, 2010.
Torcotte and Schubert, Geodynamics, Cambridge University Press, 2002

MIS (CMMACS): 3-110	Introduction to Non Linear Dynamics Course Coordinator – Dr. T R Ramamohan	2-1-0-3

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

Recommended Books
1. Julien C.Sprott , “Chaos and Time-series Analysis”, Oxford University Press 2003;

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

MIS (CMMACS): 3-111	Advanced Information Security Course Coordinator – Dr. G K Patra	2-1-0-3

Divisibility, Euclidean Algorithm, Congruence’s, Finite Fields, Quadratic Residues and Reciprocity, Primality algorithm, One-way and Trapdoor Functions, Stream Ciphers, Pseudo-Random Number Generators, Block Ciphers and Modes of Operations, Data Encryption Standard.

Private Key Encryption, Public Key Encryption, RSA Cryptosystem, Rabin’s Public Key Cryptosystem, Knapsacks, Message Authentication and Hash Functions, Digital Signatures, RSA Digital Signature Scheme, El Gamal’s Scheme, Rabin’s Scheme.

Key Distribution, Diffie-Hellman Secret Key Exchange, Two-Party and Multi-Party Protocols, Simultaneous Secret Exchange Protocol, Secret Sharing, Neural and Quantum cryptography.

Cryptanalysis of cryptographic primitives and protocols, such as by side-channel attacks, differential cryptanalysis, or replay attacks; and cryptanalytic techniques on deployed systems etc.

Security protocols at application level, Socket layer and Network layer, Virtual private networks.

Suggested Readings

- Bruce Schneier, Applied Cryptography: Protocols, Algorithms, and Source Code in C, Second E/d, John Wiley & Sons, 1996.
- William Stallings, Cryptography and Network Security: Principles and Practice, Second Edition, Prentice Hall, 1998.
- Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag.
- A. J. Menezes, P. C. van Oorshot and S. A. Vanstone: Handbook of Applied Cryptography, CRC Press.
- Shafi Goldwasser, Mihir Bellare, Lecture Notes on Cryptography. www.cse.ucsd.edu/~mihir/papers/gb.html
- O. Goldreich, Foundations of Cryptography: Basic Tools, Cambridge University Press.

MIS (CMMACS): 2-112	Network Security and Cryptography Course Coordinator – Dr. G K Patra	2-1-0-3

Introduction to Computer Security

Threats of viruses, worms, malicious codes, etc., models of propagation and their epidemic spread, dos attacks, defenses against hacking, DDoS

Theory, foundations, and applications of modern cryptography. One-way functions; encryption; authentication; symmetric cryptography, asymmetric cryptography: message authentication codes, multi-party cryptographic protocols, key exchange and applications; cryptanalysis of cryptographic primitives

Intrusion Detection and Network Security

Lab Courses on Security Tools

Suggested Readings

1. William Stallings, "Cryptography And Network Security – Principles and Practices", Prentice Hall of India, Third Edition, 2003.
2. Bruce Schneier, "Applied Cryptography", John Wiley & Sons Inc, 2001.
3. Charles B. Pfleeger, Shari Lawrence Pfleeger, "Security in Computing", Third Edition, Pearson Education, 2003.

MIS (CMMACS): 3-113	Finite Element Method Course Coordinator : Prof P Seshu	3-0-0-3

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

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

Two dimensional finite element formulation. Isoparametry and numerical integration.

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

Recommended Books

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

MIS (CMMACS): 3-114	Numerical Weather Prediction Course Coordinator : Dr V Rakesh	2-0-2-3

Governing equations - Numerical representation–numerical stebility-Computational grids - Vertical Coordinates - Sub-gridscale processes (parameterizations)- Data assimilation-Assimilation techniques: optimal interpolation, 3 and 4 dimensional variational data assimilation, etc.-Widely used numerical weather prediction models, their construction and application to forecasting and data assimilation - Global vs. Limited Area Models –Coupled models- Post-processing of model output-Gridded Forecast Verification and Bias Correction - Downscaling of

numerical model outputs - Ensemble Forecasting

Recommended Books:

Jean Coiffier 2011: Fundamentals of Numerical Weather Prediction, Cambridge University Press, 368 pp.□E. Kalnay, 2002: Atmospheric Modeling, Data Assimilation and Predictability, Cambridge, 364pp.

R. A. Pielke, 2002: Mesoscale Meteorological Modeling, 2ndEd., Academic, 676pp.□G. J. Haltiner and R. T. Williams, 1980: Numerical Prediction and Dynamic Meteorology, 2ndEd., Wiley, 477pp.

MIS (CMMACS): 3-115	**Statistical Physics and its Practical Applications** **Course Coordinator : Prof V K Gaur**	**3-0-0-3**

Most Emergent (sudden appearance at some stage of evolution) phenomena in Physical, social, industrial and environmental arenas are the integral result of a host of interacting processes at varying space and time scales, and are therefore inherently stochastic. The principal challenge in dealing with such phenomena lies in our ability to reliably estimate the Canonical states of a composite system required both for enhancing our understanding of the critical stages preparatory to their emergence as well as for designing resilient mitigative measures to minimize heir adverse impacts, if any. The concepts and methodologies of Statistical Physics open up illuminating analytical approaches to addressing a host of s problems related to such emergent phenomena: Atmospheric and ocean eddies, earthquakes, epidemics, financial market crashes, to name a few. It is accordingly proposed to design and deliver a course on STATISTICAL PHYSICS AND ITS PRACTICAL APPLICATIONS as a component of the AcSIRprogramme. The following is a first cut statement of course content which would form the basis for a more detailed and more evocatively addressed context that would subsequently be brainstormed and honed.

Course Contents:

1. Statistical methods: random variables, random functions, distributions, random walk, limit theorems

2. Statistical physical systems: Microscopic state of classical and quantum system, fundamental postulates of statistical mechanics, ergodic theorem

3. Microcanonical ensembles, thermal and mechanical interaction between to microscopic systems, connection between microcanonical ensemble and thermodynamics, classical monatomic gases

4. Canonical ensemble: Einstein solid, particles with two energy levels, Boltzmann gas

5. Classical gas in canonical formalism: Ideal monatomic gas, Maxwell-Boltzmann distribution, partition function, equipartition of energy, classical monatomic gas of particles

6. The grand canonical and pressure ensembles: pressure ensemble, the grand canonical ensemble

7. Phase transition and critical phenomena: Simple fluids. Van der Wall's equation, Landau phenomenology

8. The Ising model: Exact solution in one dimension, mean field approximation for the Ising

model, The Curie-Weiss model, The Bedther-Peierls approximation

9. Scaling theories and the renormalization group: scaling theory of thermodynamic potentials, scaling of the critical correlations, The Kadanoff construction, Renormalization of iIsing model, The general scheme of the renormalization group

10. Nonequilibrium phenomena: Boltzmann's kinetic equation, BBGKY hierarchy, Brownian motion, Langevin equation, The Fokker-Plank equation, the master equation, the kinetic Ising equation, the Monte Carlo method

11. Porous media: Relating heat, mass balance and momentum at pore scale to watershed, environmental applications

12. Data-driven modeling using statistical physics methods in nonlinear and multiscale systems: earthquakes, atmospheric instabilities, epidemics etc.

Books:

Salinas, SRA,. Introduction to Statistical physics, Springer, 2004. Huang, K. Statistical mechanics, J Wiley, 1987 Chandler, D. Introduction to modern statistical mechanics, Oxford Univ Press, 1987 Honerkamp,J. Statistical physics, Springer, 2002.65

MIS (CMMACS): 2-116	Weather and Climate Informatics Coordinator - Dr K V Ramesh	2-1-0-3

Earth system overview: Introduction to geography and natural resources, Overview of fundamentals of Earth's climate, including greenhouse effect, water and chemical cycles, outstanding features of atmospheric and ocean circulation, and feedback between different system components. Exciting and contentious scientific puzzles of climate system, like causes of ice ages, greenhouse warming, IOD, El niño etc.
Observation, analysis, modelling, forecasting and validation: Statistical analysis in climate research: probability theory, Distribution of climate variables, concepts of statistical interference, statistical test of hypothesis, analysis of atmospheric circulation problems, Forecast quality evaluation.
Application of weather informatics: Real time flood forecasting, landslide prediction, forest fire, precision agriculture: planting and fertilizer application, demand for electricity and gas, aviation etc.
Climate Change and Climate Modeling: Global environmental issues in climate change due to human activities or natural climate variations. Climate and environmental change, understand how physical geography techniques can help quantify and understand these changes, learn how to work with climate data and simple models, analyze the potential impacts of environmental change on a range of sectors including agriculture, food, forestry, water resources, energy usage, rapid change caused by natural hazard processes and human health, and discuss potential mitigation and adaptation options.
Software Lab: Introduction to basic data analysis tools. Survey of numerical methods employed in atmospheric and related sciences: theory, application, and programming.

Recommended Books

1. Environmental Issues: An Introduction to Sustainability, 3/E by Robert L. McConnell and Daniel C. Abel
2. Carson, R. (2002). *Silent Spring*, Boston: Houghton Mifflin Company.
3. Harris, J.M. (2006). *Environmental and Natural Resource Economics*, 2nd edition, Boston: Houghton Mifflin.

4. Meadows, D.H. *et al.,* (2004). *The Limits to Growth: the 30-year Update*, The Chelsea Green Publishing Company.
5. Perman, R., May, Y., McGilvray, J. and Common, M. (2003). *Natural Resource and Environmental Economics*, 3rd edition, Harlow: Pearson Education.
6. Statistical analysis in climate research By Hans von Storch, Francis W. Zwiers.

NAL

Course No.	Title	L	T	P	C
	Electives				
MIS601	Fundamentals of Electronic Materials & Semiconductor Devices	3	0	2	4
MIS602	Physics & Technology of Thin Films	3	0	2	4
MIS603	Advanced Materials Characterization Techniques	3	0	2	4
MIS604	Nanostructured materials	2	1	2	4
MIS605	Superconductivity & Magnetic Materials	3	0	2	4
MIS606	Advanced Measurement Techniques & Metrology	3	0	2	4
MIS607	Advanced Computational Physics	3	0	2	4
MIS609	Engineering Materials	3	0	2	4
MIS701	Quantum Optics & Advanced Solid State Optical Devices	3	0	2	4
MIS702	Advanced Self Study on Special topic	2	2	0	4

Principal Faculty (Partial List)

1. Prof. R M Jha
2. Prof. V Mudkavi

CSIR National Aerospace Laboratories (NAL)
Engineering Electromagnetics

Vectors and Fields: Coordinate systems, sinusoidally time-varying fields; **Maxwell's equations** and uniform plane waves: integral form, differential form, boundary conditions, solution of wave equations; **Uniform plane waves** in lossless and lossy media, Poynting vector, Polarization, Reflection, Refraction, and Diffraction in Uniform Plane Waves, Normal and oblique incidence; **Modes of Propagation** in Waveguides: Rectangular Waveguides, Cylindrical Waveguides, Cavity Resonators; **Transmission lines**, Stub Matching, Smith Charts; **Antenna Fundamentals:** Gain, Radiation Pattern, Polarization, Effective Aperture Types of Antennas, Antenna Arrays; **Microwave Sources:** Klystron, Gunn diode, Travelling wave tube, Solid-state sources: IMPATT, TRAPATT, BARITT

Suggested Readings

1. *Electromagnetic Waves & Radiating Systems.* E. D. Jordan and K.G. Balmain, 2nd ed., Prentice Hall of India Pvt. Ltd., 1976.
2. *Antenna Theory: Analysis and Design.* C. A. Balanis, John Wiley & Sons, 1982.
3. *Field Theory and Guided Waves.* R.E. Collin, 2nd ed., IEEE Press, NewYork, 1991.

Computational Design with Metamaterials

Concepts in Metamaterials (MTM): Negative refractive index, reversal of Doppler Effect and Vavilov-Cerenkov radiation, and Snell's law, boundary conditions; Types of MTMs: Double-Negative (DNG) MTMs, Left Handed MTMs, Photonic Band-Gap (PBG) structures, Electromagnetic Band Gap (EBG) Metamaterials; Methods of Analysis of MTMs: Finite Difference Time Domain (FDTD), Plane Wave Method, Transfer Matrix Method (TMM), Transmission Line Method (TLM); Design of Metamaterial based radomes, Frequency Selective Surfaces (FSS) and radar absorbent structures (RAS), MTM based antenna arrays; Plasmonic nanowire metamaterial structures; Negative Refractive Index (NRI) Transmission Line (TL) lenses: Propagation characteristics, conditions for perfect imaging in the NRI-TL Lens, Reflection and Transmission through the lossless NRI-TL Lens, Super-resolving NRI Transmission-Line Lens, Aberrations;
Negative Refraction and Sub-wavelength imaging in Photonic Crystals; Design in microwave, IR and optical frequency ranges.

Suggested Readings

1. *Negative-Refraction Metamaterials: Fundamentals Principles and Applications.* ed. G.V. Eleftheriades and K.G. Balmain, IEEE Press, NJ, 2005.
2. *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications*. C. Caloz and T. Itoh, IEEE Press, NJ, 2006.
3. *Metamaterials: Physics and Engineering Explorations.* ed. N. Engheta and R.W. Ziolkowski, IEEE Press, NJ, 2006.

Engineering Applications of Metamaterials

Design of Metamaterial (MTM) based transmission line: Theoretical background, periodically loaded Negative Refractive Index (NRI) Transmission Line (TL) MTM, dispersion characteristics, impedance match condition; Microwave devices and antennas using NRI-TL MTMs: effective

medium theory, super-resolving NRI-TL lens, compact and broadband phase-shifting lines, series-fed antenna arrays with reduced beam squinting, broadband metamaterial balun, power combiners, electrically small antenna, leaky-wave backward antenna, microstrip coupler, resonators; MTM-Cloaking devices, MTM based FSS, MTM based low observable platforms, MTM based absorbent coating in IR and optical domain; Optical MTMs, Terahertz Magnetics MTMs, Surface Plasmonic MTMs, Active MTMs.

Suggested Readings

1. *Negative-Refraction Metamaterials: Fundamentals Principles and Applications.* ed. G.V. Eleftheriades and K.G. Balmain, IEEE Press, NJ, 2005.
2. *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications.* C. Caloz and T. Itoh, IEEE Press, NJ, 2006.
3. *Metamaterials: Physics and Engineering Explorations.* ed. N. Engheta and R.W. Ziolkowski, IEEE Press, NJ, 2006.

Engineering Design of Artificial Dielectrics

Basic concepts of dielectrics: Complex permittivity, dielectric loss, dielectric relaxation, dielectric breakdown. Polar and non-polar dielectrics; Polarization: Space charge polarization, dipolar polarization, ionic polarization, electronic polarization. Dielectric properties of mixtures; Lorentz theory, electrostatic solutions, evaluation of interaction constants, sphere-and disk-type artificial dielectrics, transmission line approach for disk medium, two-dimensional strip medium; Types of artificial dielectrics: anisotropic materials, bi-anisotropic materials, chiral media, honeycomb structures, inhomogeneous planar layers; Dielectric fillers, metallic wire grid/ mesh embedded structures, resonant and semi-resonant inclusions; Applications of artificial dielectrics in the design of radomes and RAS.

Suggested Reading

1. *Dielectrics in Electric Fields*, G. G. Raju, Marcel Dekker, Inc., 2003.
2. *Field Theory of Guided Waves,* R. E. Collin, 2nd ed., IEEE Press, NY, 1991.
3. *Analytical Modeling in Applied Electromagnetics,* S. Tretyakov, Artech House, Norwood, MA, 2003.

Design and Analysis of Radar absorbing Materials (RAM) and Structures (RAS)

Concepts in Radar cross section (RCS), Radar range equation; Stealth techniques; Radar Absorbing Materials (RAM) and its ideal requirements; Fundamental EM concepts for RAM: Maxwell's equation, surface boundary conditions, constitutive relations, EM wave propagation through free space, homogeneous, inhomogeneous medium, EM parameters for RAM; Mathematical analysis for RAM on surfaces: Reflection at planar boundary, curved boundary, grid-based methods, high-frequency methods; EM design of RAM and Radar Absorbing Structures (RAS): narrowband absorbers, broadband absorbers, realization of RAM in practice; Absorber Characterization Techniques: measurement of material properties, free space techniques; Identification and applications of RAM; Trends in RAM.

Suggested Readings

1. *Radar Absorbing Materials: from Theory to Design and Characterization*. K. J. Vinoy, and R. M. Jha, Kluwer Academic Publishers, Boston, MA, 1996.

2. *Radar Cross Section*. E. F. Knott, J. F. Shaeffer, and M. T. Tuley, Artech House, Dedham, MA, 1965.
3. *Radar Cross Section Lectures*. A. E. Fuhs, New York: AIAA, 1982.

Surface Modeling and Ray Tracing Applications

Coordinate systems, coordinate surfaces and shaping parameters: Second degree coordinate systems, Eisenhart coordinate systems; cylindrical coordinate systems (rectangular, circular-cylinder, elliptic-cylinder, parabolic-cylinder), rotational coordinate systems (spherical, prolate spheroidal, oblate spheroidal, parabolic), general coordinate systems (conical, ellipsoidal, paraboloidal); Other coordinate systems for engineering applications: Bispherical coordinate system, and ogive; Coordinates transformations, Geodesic coordinate system, Hybrids of coordinates surfaces for practical applications; Ray tracing concepts, ray casting, ray launching, Ray surface interactions, edge interactions; Applications of ray tracing: scattering characteristics, indoor/outdoor environment analysis.

Suggested Readings

1. *Field Theory Handbook: Including Coordinate Systems Differential Equations and their Solutions*. P. Moon and D. E. Spencer, 2nd edition, Springer-Verlag, Heidelberg, 1971.

2. *An Introduction to Differential Geometry*. T.J. Willmore, Oxford University Press, Oxford, 1959.

Ray Tracing and Geometrical Theory of Diffraction

Application of Ray tracing in various science and engineering disciplines; Overview of various ray tracing techniques; Ray-theoretic Formulation, Geometrical Optics; Scattering and diffraction, Diffraction by canonical structures, Surface-, Edge-, and Tip-diffraction; Surface modeling and Ray Tracing, Coordinate Systems and Coordinate Surfaces; Analytical Surface Generation, Geodesic coordinate system and Geodesic Constant Method (GCM); Ray tracing techniques over canonical coordinate surfaces and hybrid (composite) surfaces; Geometrical Theory of Diffraction (GTD) and its extensions; Ray tracing over quadric cylinders and surfaces of revolution; Ray tracing over general surfaces, including a minimum of two Seminars.

Suggested Readings

1. *An Introduction to Differential Geometry*. T.J. Willmore, Oxford University Press, Oxford, 1959.
2. *Geometric Theory of Diffraction*. Ed. R. C. Hansen, IEEE Press, New York, 1981.

3. *Geometrical Theory of Diffraction for Electromagnetic Waves*. G.L. James, Peter Peregrinus, Stevenage, UK, 1976.

Design of Conformal Antenna Arrays

Fundamentals of conformal antennas: circular array theory; Shapes of conformal antennas: 360 degree coverage, hemispherical coverage, multifaceted surfaces; Method of analysis: electrically

small surfaces, electrically large surfaces; Conformal array radiation characteristics: mechanical considerations, radiation pattern, polarization, array impedance; Geodesics on curved surfaces: singly curved surfaces, doubly curved surfaces, arbitrarily shaped surfaces, mutual coupling effect; Antenna on singly curved surfaces: aperture antennas on circular cylinders, aperture antennas on general convex cylinders, aperture antennas on faceted cylinders, aperture antennas on dielectric coated circular cylinders, microstrip-patch antennas on coated circular cylinders, conical antenna array; Conformal antennas on doubly-curved surfaces and practical shapes.

Suggested Readings

1. *Conformal Array Antenna Theory and Design*. L. Josefsson and P. Persson, IEEE Press, NJ, 2006

Design and Analysis of Radomes

Basics of radome performance parameters: Power transmission, power reflection, insertion phase delay, boresight error, antenna pattern degradations; Classification of radome wall configurations: Radome types, Classes and Styles. Monolithic and multilayered structures; Radome materials: Organic radome dielectric materials, Foam materials, inorganic radome dielectric materials, Dual-mode radome materials; Radome design techniques: Constant thickness design and variable thickness designs. Broadband radome designs; Radome analysis techniques: Geometrical Optics (GO) methods, Physical Optics (PO) methods, plane wave spectrum method, finite element method, and Hybrid methods; Novel Radomes: Frequency Selective Surfaces (FSS) radomes, metamaterial radomes; Radome performance measurements: Power transmission efficiency measurements, Insertion Phase Delay (IPD) measurements, Measurements of antenna pattern degradations.

Suggested Reading

1. *Radar Scanners and Radomes.* W. M. Cady, M. B. Karelitz, L. A. Turner, McGraw-Hill, NY, 1948.
2. R.H.J. Cary, “Radomes,” in *The Handbook of Antenna Design.* A.W. Rudge, K. Milne, A.D. Olver, and P. Knight (Eds.), Peter Peregrinus, London, UK, 1982.
3. *Analysis of Radome-Enclosed Antennas.* D. J. Kozakoff, Artech House, Norwood, MA, 1997.
4. *Frequency Selective Surfaces: Theory and Design.* B.A. Munk, Wiley, New York, 2000.

Airborne Antenna Analysis

Introduction to Electromagnetic (EM) analysis of antennas over aircraft, missiles, satellite launch vehicles (SLV) and unmanned aerial vehicles (UAV); Introduction to Electromagnetic (EM) Scattering and Diffraction, Aerospace Scatterers, Surface Modeling, Analytical surface generation, EM Antenna Characteristics, Antenna mutual coupling and radiation pattern over aerospace scatterers; Overview of the Computational Methods, Application of the Method of Moments (MoM), Geometrical theory of diffraction (GTD), Uniform theory of diffraction (UTD), Hybrid methods; Diffraction by canonical structures; Ray-theoretic Formulation, Analytical surface generation, Geodesic Constant Method (GCM); EM Field Computations over General Quadric Cylinders (QUACYL) and Quadric Surface of Revolution (QUASOR); EM Field Computations over aerofoils, aircraft wings, SLV and UAV; Optimal antenna locations over aerospace structures, including a minimum of two Seminars.

Suggested Readings

1. *Geometric Theory of Diffraction*. Ed. R. C. Hansen, IEEE Press, New York, 1981.

2. *Conformal Array Antenna Theory and Design*. L. Josefsson and P. Persson, IEEE Press, NJ, 2006

Adaptive Antenna Algorithms

Adaptive antenna fundamentals, Performance parameters: Output Signal-to-noise-ratio (SNR), convergence rate, steady state analysis, Degrees of Freedoms; Beam forming networks; Antenna beam/sidelobe control; Adaptive Array Processing: Narrowband/Wideband; Sidelobe Cancellers and their performance: Conventional Generalized Sidelobe Canceller (GSC), Decision Feedback Generalized Sidelobe Canceller (DF-GSC), Blind DF-GSC; Adaptive Algorithms: Maximum Likelihood Algorithm, LMS algorithms, Recursive Least Square (RLS) algorithm, SMI algorithm; Active Cancellation in adaptive arrays; Multi-beam Adaptive Antenna Array; Correlation/Coherence between Signals; Mutual Coupling Effect; Direction-of-arrival (DoA) Estimation Methods; Adaptive antenna applications.

Suggested Readings

1. *Smart Antennas.* L.C. Godara, CRC Press, Boca Raton, Florida, 2004.
2. *Adaptive Antennas and Phased Arrays for Radar and Communications*. A.J. Fenn, Artech House, Norwood, MA, 2008.
3. *Smart Antennas: Adaptive Arrays, Algorithms, & Wireless Position Location.* Editor: T. S. Rappaport, IEEE Press, NJ, 1998.
4. *Digital Beam Forming in Wireless communications.* J. Litva and T. Lo, Artech House, Norwood, MA, 1996.

FSS Design and Analysis

Fundamentals of Frequency Selective Surfaces (FSS): FSS elements, Types of FSS, dielectric loading effect, grating lobe phenomena, Wood's anomalies; Single and multiplayer FSS, FSS structure with multiple periodicity; EM design of FSS structures: Dual-band, Multi-band, FSS performance parameters, Optimization of design and performance parameters; Methods for FSS Design and Analysis: Mode matching- Generalized-scattering matrix (MM-GSM), Method of Moments (MoM), Finite element method (FEM), Finite Difference Time Domain (FDTD) analysis, Transmission line matrix (TLM) method, Hybrid methods, Cascading of Multi-screen FSS; FSS Materials and Fabrications; Measurement Techniques; Applications of FSS: Radomes, Antennas, Radar absorbing structures (RAS).

Suggested Readings

1. *Frequency Selective Surfaces: Theory and Design*, Ben A. Munk, John Wiley and Sons, New York 2000.
2. *Frequency Selective Surfaces: Analysis and Design*, ser. Electronic & Electrical Engineering Research Studies Antenna Series, J. C. Vardaxoglou, John Wiley and Sons, New York, 1997.

3. *Frequency Selective Surface and Grid Array*. T.K. Wu, New York: John Wiley & Sons, 1995

CSIR-URDIP

Course No.	Course Title	L	T	P	C
Common Core					
MIS-URDIP-1-381	Project proposal writing	0	1	6	4
MIS-URDIP-1-382	CSIR-800 Societal Programme	0	0	8	4
Programme Core					
MIS-URDIP-2-383	Research Methodology	1	1	0	2
MIS-URDIP-2-384	Advanced Self Study	0	2	4	4
Electives					
MIS-URDIP-3-385	IP Management	2	1	0	3
MIS-URDIP-3-386	R&D Management	2	1	0	3
MIS-URDIP-3-387	Technology Management	2	1	0	3
MIS-URDIP-3-388	Patinformatics	2	0	1	3
MIS-URDIP-3-389	Cheminformatics	2	0	1	3
MIS-URDIP-3-390	Bioinformatics	2	0	1	3

CSIR-Unit for Research and Development of Information Products (CSIR-URDIP)

Institutional Profile:

CSIR's specialized service unit - Unit for Research and Development of Information Products (CSIR-URDIP), is involved in pre-research and pre-development phase of research programmes by providing intellectual property and techno-commercial information services. URDIP's research output is used as input by R&D, legal, new business development and multifunctional teams for Research and Business Planning. URDIP has about 10 years of experience in informatics activities which includes extracting and analyzing technical/scientific knowledge in published patents, patent applications, literature references such as scientific journals, Internet and other publicly available information sources; including obtaining and analyzing commercial information that is publicly available. In addition, URDIP is involved in the creation of subject specific databases as per needs of stakeholders. The core activities of URDIP include*: Patinformatics, Chembioinformatics, Phytoinformatics, Toxinformatics and Web-based services.*

URDIP does research in the area of Research, Technology, Knowledge and Intellectual Property Management. URDIP is recognized by University of Pune as a research center for PhD research in *Intellectual Property and Knowledge Management.*

Ph.D. students will be admitted into Ph.D. (Science) at the moment. The academic credit requirement of the students (total of 20 credits) is made up of three components as explained below.

1. Common Core (8 credits)

Every PhD student, irrespective of his/her background and the programme of study, has to fulfill the following requirements

(a) MIS-URDIP-1-381: Project proposal writing

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

(Activity Coordinator: PhD Guide)

(b) MIS-URDIP-1-382: CSIR-800 Societal Programme

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions.

Alternatively students admitted at URDIP will be permitted to undertake one of following activities:

Create a database of patents which have come into public domain (Expired Patents, Non-jurisdiction Patents, Patents not granted, abandoned applications and Invalid Patents). This database then can be used to Support CSIR-800 programme to solve societal problems quickly. Similar database can also be used to support MSME sector as most of them use old techniques of production and outdated machinery and equipment.

The priority will be the areas already identified and referred by the Coordinator of CSIR-800 programme or the laboratories involved in CSIR-800 programme. Based on the identified areas and needs, student will build a problem/subject specific database and share it with scientists/technologists working on the particular project.

Alternatively, problem will be chosen from one of the clusters identified under the CSIR Cluster Innovation programme.

An opportunity assessment study or a techno-economic survey that will benefit rural economy.

Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

(Activity Coordinator: Mr. P. S. Malwadkar)

2. Programme Core (6 credits)

(a) MIS-URDIP-2-383: Research Methodology *

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

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

(Course Coordinator: Dr P. Goswami)

*****This course will be the one already designed by CMMACS and designated as MIS(CMMACS)-101 or the one to be designed by NISTADS and named as Research Methodology-II (Qualitative and Critical Studies).*

(b) MIS-URDIP-2-384: Advanced Self Study

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

(Course Coordinator: PhD Guide)

In lieu of Advanced Self Study, students will be free to choose from any of the core courses offered by any of the laboratory in the MIS cluster/ under MIS faculty in consultation with Doctoral Advisory Committee.

3. Programme Electives (6 credits)

Any of the following courses may be chosen appropriately to fulfill the total credit requirements.

Course No.	Course Title	L	T	P	C
Common Core					
MIS-URDIP-1-381	Project proposal writing	0	1	6	4
MIS-URDIP-1-382	CSIR-800 Societal Programme	0	0	8	4
Programme Core					
MIS-URDIP-2-383	Research Methodology	1	1	0	2
MIS-URDIP-2-384	Advanced Self Study	0	2	4	4
Electives					
MIS-URDIP-3-385	IP Management	2	1	0	3
MIS-URDIP-3-386	R&D Management	2	1	0	3
MIS-URDIP-3-387	Technology Management	2	1	0	3
MIS-URDIP-3-388	Patinformatics	2	0	1	3
MIS-URDIP-3-389	Cheminformatics	2	0	1	3
MIS-URDIP-3-390	Bioinformatics	2	0	1	3

In addition to above, students will be free to choose from any of the core and optional courses offered by any of the laboratories under AcSIR relevant to topic of their thesis in consultation with Doctoral Advisory Committee.

DETAILS OF ELECTIVE COURSES

1. MIS-URDIP-3-385: IP Management

Historical overview of IP systems

The patent power - What is a patent – Types of patents – Why patent? – How does the patent system work? Types of applications –Common myths about patents (duration, ownership, freedom to practice, secrecy, global patent, geographical boundaries) – Infringement – Damage awards - Industry structure and importance of patent – Leveraging patents as financial assets – Perils of ignoring patents – IP savvy organizations

Requirement of a patent – Criteria for patenting – subject matter, novelty, non obviousness, utility – Enablement, Best mode, Definiteness- Unity of inventions- Inventorship - Statutes – Interpretation – Infringement-Case studies

Abstract – Specification – Written description – Claims – Independent and dependent claims – Swiss claims – Length of a document – Claim drafting with file Estoppel in mind – Capturing invention

Should a patent be filed? – Where to file – Criteria – When to file? - Timing and filing – Foreign filings – The PCT route – Drafting the application – USPTO procedures – Manipulating patent filing and prosecution process – Maintaining secrecy for longer - Fighting competition – Importance of record keeping.

Goals of patent strategy – types of strategies – Shield and sword patents – Protecting markets, Company and future – Protecting single invention – Multiple inventions – Bracketing, clustering and fencing - Strategy for existing products – Patent investment strategies for commercializing technology - Aligning patent strategy with business strategy – Business driven patenting strategy extending the life of invention – Transferring IP assets to business assets – Invention, product and market considerations – Market economies and technology density considerations – Organizing patent portfolio – Enhancing patent quality – Patent cost management – Benchmarking patent strategy against competition – Patent strategy for long term growth – Patent strategy for building corporate assets and exploiting the same – Case studies

Conventional flow path for product development – Gaps analysis for R&D planning – New model – From pure research to commercial development – Market pull vs. research push

Role of IP in M&A decisions — IP due diligence for M&A – Negotiating value – Case studies
Approaches to exploiting IP –When licensing is the preferred option – Rationale for licensing – Objectives of licensing – Carrot and stick licensing, - Licensing decision – factors governing licensing and financial compensation – Approaches to IP valuations – Sharing profits – Cost based valuations – Market based valuations- Industry standards -Researching the markets and targets – Scope of licensing – Exclusive/ non exclusive, territories, duration, non competitive clauses – sublicensing – improvements – cross licensing, - Preparing for negotiations – Steps and processes for negotiation – Responsibilities of the licensor and licensee – Draft agreements – Typical drafts – Licensing as a business strategy in chemical industry – Licensing practices at leading companies - Trends in IP and licensing management – Case studies

Levels of IP exploitation in organization – moving up the value chain - organization – From filing to transacting – Transformation at Xerox, Dow Chemicals, P&G.

(Course Coordinator - Dr. M. G. Kulkarni)

Suggested reading

1. Rivette, K.G. - Rembrandts in the attic: unlocking the hidden value of Patents –-Boston: Harvard Business School Press, 2000
2. Knight,H.J. - Patent strategy: for researchers and research managers -Chichester: John Wiley and Sons, 2001
3. Goldstein, A.N. Ed. - Patent law for scientists and engineers - Boca Raton: Taylor and Francis, 2005
4. Junghans, C. - Intellectual property management: a guide for scientists, engineers, financers and managers - Weinheim: Wiley Vch, 2006
5. Miller, C.P. - Chemist's companion guide to patent law - Hoboken: John Wiley & Sons, 2010
6. Alexander I. Poltorak, Paul J. Lerner - Essentials of Intellectual Property - John Wiley & Sons Inc, 2002. ISBN: 9780471209423
7. Ganguli, Prabuddha - Gearing up for patents: The Indian scenario - Universities Press (India) Limited, 1998. ISBN: 8173711054
8. Junghans, C.; Levy, Adam - Intellectual property management: A Guide for Scientists, Engineers, Financiers and Managers - Wiley-VCH Verlag GmbH & Co. KGaA, 2006. ISBN: 9783527312863

2. MIS-URDIP-3-386: R&D Management

Conceptual framework of R&D management – Origins of industrial R&D – The industrial R&D process - Changing role of R&D in industry - Role of R&D in technological innovation - Implications for R&D strategy – Formulating R&D strategy – Evolution of corporate R&D – Centralized vs decentralized R&D – Organizational structure for R&D - Input and output oriented structures – Critical activities of R&D function - Role of leadership - Components of R&D organization – Make vs buy decision - R&D project management - R&D project portfolio - Resource allocation for R&D – Managing value and risk in R&D portfolio Aligning R&D portfolio with business strategy - Planning directed basic research - Globalization of R&D- Implications for corporate R&D - Coordinating multi locational R&D Location strategies – Global R&D centres in India - From first to fourth generation R&D - Project selection and evaluation - Evaluation of R&D performance – R&D performance metrics – R&D performance effectiveness and impact - Decision support systems for R&D project management – Terminating R&D projects - Post project evaluation and learning - Trends in R&D management – Open Innovation- Working with national innovation systems – Directed basic research with universities - Managing R&D collaborations – Issues in value based R&D Case studies in R&D management - 3M, DuPont, GE, P&G , Merck.

(Course Coordinators: Dr. M. G. Kulkarni / Dr. R. R. Hirwani)

Suggested reading

1 Saunders, J.H. - Careers in industrial research and development - 1974
2 White, P.A.F. - Effective management of research and development - 1975
3 Rawat, A. - Management of corporate R & D and innovation - Global Business Press, Delhi, 1995
4 Bamfield, P. - Research and development management in the chemical industry – Vch Verlagsgesellschaft Mbh, Weinheim, 1996
5 Cohan,P.S. - Technology leaders: How America's most profitable high tech companies innovate their way to success - Jossey Bass Inc., San Francisco, 1997
6 Chiesa,V. - R and D strategy and organization: managing technical change in dynamic contexts - London: Imperial College Press, 2001
7 Martin, M.J.C. - Managing innovation and entreneurship in technology based firms - Wiley Interscience, New York, 1994
8 Miller, W.L. - Fourth generation R and D: managing knowledge, technology and innovation - John Wiley And Sons Inc, New York, 1999
9 Reddy, P. - Globalization of corporate R & D: implications for innovation systems in host countries - Routledge, London, 2000

10 Harvard Business School - Harvard business review on managing projects - Harvard Business School Press, Boston, 2005

3. MIS-URDIP-3-387: Technology Management

Concept and framework of technology management - Strategic role and scope of technology management – Technology life cycles and flow processes- S curves in technological progress – Technology push vs. market pull – Product life cycles – Technology diffusion

The technology environment – Industry structure – Organizational structure – resources – Competitive advantage at firm and national level

Product, technology and business strategy – Aligning strategies

The positioning approach – Resource based approach – Rationalist and incrementalist approach Technology selection –Timing – Acquisition or development – Make vs. buy decision – Types of technology strategies

Models of technology growth and diffusion – Forecasting techniques and tools – Managing forecasting process – case studies from industries – Technology monitoring – Trend analysis techniques and tools – Simulation and scenario building – Economic forecasting and analysis – Forecasting directions and changes – Forecasting technological discontinuities and change

Mapping technological environment – competitor activities –assessing technological positions - Technology analysis – Technology base of the firm - Technology planning and business strategy - - The planning process – Case studies from chemical industries

Profit sharing – Cost basis – Market basis – Economic assessment- DCF analysis to estimate present value

Modalities of acquisition – Joint ventures – outsourcing - Licensing – Discipline of acquisition – Role of management – Factors influencing managerial decision – selecting partners – Case studies
The licensing decision – Licensing strategies – Due diligence prior to licensing - Licensing agreements – Negotiating and drafting – Model agreement- Post licensing activities - Licensing from universities – case studies

Technology transfer, Technology management case studies, developing technology managers.

(Course Coordinator- Dr. R. R. Hirwani)

Suggested reading

1. Gaynor,G.H._Ed. - Handbook of technology management - Mc-Graw Hill, New York, 1996
2. Betz, F - Strategic technology management - Mc-Graw Hill, Inc., New York, 1993
3. Boer, F.P. - Valuation of technology: business and financial issues in R and D - John Wiley and Sons, New York, 1999
4. Megantz, R.C. - Technology management: developing and implementing effective licensing programs - John Wiley and Sons, New York , 2002
5. Khalil, T.M. - Management of technology - Mc Graw Hill Book Co., Singapore, 2000
6. Narayanan, V.K. - Managing technology and innovation for competitive advantage - Pearson Education Inc., Delhi, 2001
7. Szakonyi, R. Ed - Technology management, Auerbach, 1999
8. Porter, A.L. - Forecasting and management of technology - Wiley Interscience, New York, 1991

9. Martin, M.J.C - Managing innovation and entreneurship in technology based firms - Wiley Interscience, New York, 1994
10. Phaal, R. - T plan: the fast start to technology road mapping planning your route to success - Institute of Manufacturing, University of Cambridge, Cambridge, 2001

4. MIS-URDIP-3-388: Patinformatics

Introduction to IPR, Understanding Patents and Patent Legislation – Requirements of Patentability, Patent Treaties,

Reading a patent -– Anatomy of a patent and implications - Dissecting the parts – Independent and dependent claims – Claim interpretation – Evaluating strengths and weaknesses of a patent – The file history and implications

Introduction to Patinformatics – Patent Families, Patent Citations- Relationships and Trend Analysis- Patent Intelligence – Patent Searching-Types of searches- Patentability – Validity – Infringement – Clearance (FTO)- State of the art – Landscape search –Search methodologies – Key word searches-Patent classification systems, Introduction to patent databases (Free and Paid), Searching on various patent databases, Patent analysis and mapping, Patent analysis and mapping tools, Patent information for strategic planning and technology management, Patent indicators and patent statistics for policy making, Planning R&D investments and measuring R&D performance

Hands-on – Patent searching, Patent search and analysis reports for various end uses.

(**Course Coordinator- Ms. Rashmi Phadnis)**

Suggested reading

1. Adams, Stephen R. - Information Sources in Patents - K G Saur Verlag, 2005. ISBN: 9783598244438
2. Hunt, David; Nguyen, Long; Rodgers, Matthew - Patent Searching: Tools & Techniques - John Wiley & Sons, Inc., 2007
3. Hitchcock, David - Patent Searching Made Easy : How to Do Patent Searches on the Internet & in the Library - Nolo, 2009. ISBN: 9781413310368
4. Gibbs, Andy; DeMatteis, Bob. - Essentials of Patents - John Wiley & Sons, Inc. 2003. ISBN: 9780471250500

5. MIS-URDIP-3-389: Cheminformatics

Introduction to cheminformatics: aims, scope- Role of Cheminformatics in pharmaceutical / chemical research- Representation and manipulation of 1D, 2D and 3D molecular structures.- Molecular file formats (SMILES, WLN, SDF, MOL), Molecular patterns- SMARTS, SMIRKS- Molecular descriptors - Calculation of descriptors reflecting physical and chemical properties of the molecules, including fingerprints and methods used for evaluation of molecular similarity and for selection of structurally diverse and representative subsets Properties - Calculation of physico-chemical properties such as solubility and partition coefficients, pharmacological properties such as absorption and distribution, and global properties such as oral bioavailability and "drug-likeness" data analysis- Molecular similarity and molecular diversity analysis. Similarity index- Molecular Database Screening: (Lipinski Rule: Drug/Lead like molecules) Clustering and Statistical analysis for Molecular Informatics (PLS, PCA, PCR, kNN, ANN, Correlation and regression analysis) - Modeling of small molecules using molecular mechanics and quantum mechanics methods. Quantitative structure activity relationship (QSAR), Quantitative structural

property relationship (QSPARs), Quantitative structural Toxicity Relationship (QSTR), Pharmacophore modeling- In silico virtual screening- Docking studies.

(Course Coordinator- Mr. R. C. Dash)

Suggested reading

1. Leach, Andrew R.; Gillet, Valerie J. - An introduction to Chemoinformatics - Kluwer Academic Press, 2003. ISBN: 1402013477
2. Bunin B.A. et al. - Chemoinformatics: Theory, Practice, & Products - Spingerlink, 2007. ISBN 978-1-4020-5000-8
3. Gasteiger, Johann; Thomas, Engel - Chemoinformatics: A Textbook - Wiley- VCH, 2003. ISBN: 3527306811.
4. Oprea, Tudor I. - Chemoinformatics in drug discovery - Wiley-VCH, 2005
5. Ekins, Sean, ed. - Computer Applications in Pharmaceutical Research and Development - Wiley, New Jersey, 2006

6. MIS-URDIP-3-390: Bioinformatics

What is bioinformatics, Basic concepts, Sequence, structure and function, Bioinformatics databases, Type of databases, Secondary nucleotide sequence databases, Sequence motif databases, Protein structure databases, Other relevant databases such as KEGG, DockGround, Sequence alignment and database searching, scoring matrix, Dynamic programming, Heuristic methods, Statistics of sequence alignment score, Multiple sequence alignment, Hidden Markov Models.

Protein structure alignments, structure superposition, RMSD, Different structure alignment algorithms, Protein secondary structure predictions, Protein tertiary structure modelling, Protein folding and dynamic simulation, Comparative modelling, Threading, Combined modelling approaches, Protein quaternary structure modelling.

Rapid development programming languages (Python, Perl), relational databases (SQL), Java, exploratory data analysis in R.

Techniques for designing efficient algorithms and basic mathematical methods for analyzing their performance. Paradigms for algorithm design: divide-and-conquer, greedy methods, graph search techniques, dynamic programming. Protein-protein docking algorithms, Semi-flexible docking: Side-chain refinement, Protein-ligand docking algorithms, Multiple-threading algorithms.

(Course Coordinator: Mr. Nishad Deshpande)

Suggested reading

1. Mount, David. Bioinformatics: Sequence and Genome Analysis. CSL Press, 2004. ISBN:0-87969-687-7
2. Husmeier, Dirk et al. - Probabilistic Modeling in Bioinformatics and Medical Informatics - Springer, 2004. ISBN: 1-85233-778-8
3. Rigden, Daniel - From Protein Structure to Function with Bioinformatics, Springer, 2009. ISBN: 978-90-481-8058-5
4. Gu , Jenny; Bourne , Philip E. - Structural Bioinformatics. Wiley, 2009 ISBN-13: 978-0-470-18105-8
5. Model, Mitchell L. - Bioinformatics Programming Using Python Practical Programming for Biological Data, O'Reilly Media, 2009. ISBN-978-0-596-15450-9
6. Tisdall, James D. - Beginning Perl for Bioinformatics: An Introduction to Perl for Biologists. O'Reilly Media, 2001. ISBN-978-0-596-00080-6
7. Bal, Harshawardhan; Hujol, Johnny. - Java for Bioinformatics and Biomedical Applications. Springer, 2006. ISBN-13: 978-0-387-37237-8

AcSIR-NISCAIR COURSES

Ph.D (Engg. & Science) in Computational Biology & Bioinformatics (CBB)

1. Common Core & Programme Core (14 Credits)

S.No.	Course No.	Course Title	L-T-P-C
01.	MIS-NISCAIR-1-311	Research Methodology	1-1-0-2
02.	MIS-NISCAIR-3-312	Advanced Self Study	0-2-4-4
03.	MIS-NISCAIR-4-313	Project Proposal Writing & Review Article	0-1-6-4
04.	MIS-NISCAIR-4-314	CSIR-800 Societal program	0-0-8-4

2. Programme Electives (6 Credits)

S.No.	Course No.	Course Title	L-T-P-C
01.	MIS-NISCAIR-2-315	Basic & Advance Bioinformatics	2-1-0-3
02.	MIS-NISCAIR-3-316	Languages Learning in Bioinformatics	2-1-0-3
03.	MIS-NISCAIR-3-317	Database Management Systems	2-1-0-3
04.	MIS-NISCAIR-3-318	Discovery & Translational Bioinformatics	2-1-0-3
05.	MIS-NISCAIR-3-319	Genomics, Metagenomics, Proteomics & Transcriptomics	2-1-0-3
06.	MIS-NISCAIR-3-320	Computational Biology Approaches for Drug Discovery/ Drug Discovery Informatics	2-1-0-3
07.	MIS-NISCAIR-3-321	Computational Immunology / Immunoinformatics	2-1-0-3
08.	MIS-NISCAIR-3-322	Computational Neurology/Neuroinformatics	2-1-0-3

Principal Faculties:

1. **Dr. Tarakanta Jana**
2. **Shri Hasan Javed khan**
3. **Dr. S. C. Sharma**
4. **Dr. G. Mahesh**
5. **Shri S.R. Kundu**
6. **Shri Mukesh Pund**
7. **Mrs. Charu Verma**
8. **Shri Sanjay Burde**
9. **Shri C.B. Singh**
10. **Dr. Vijayalakshmi**

(B) Ph.D (Engg. & Science) in Database Systems & Climate Change Informatics (DBS & CCI)

COMMON CORE (14 CREDIT)

S.No.	Course No.	Title of the course	L	T	P	C
1.	MIS-NISCAIR-1-323	Research Methodology	1	1	0	2
2.	MIS-NISCAIR-3-324	Advance Self Studies	0	2	4	4
3.	MIS-NISCAIR-4-325	Project Proposal Writing & Review Article	0	1	6	4
4.	MIS-NISCAIR-4-326	CSIR-800 Societal Program	0	0	8	4

Programme Electives (6 Credits)

S.No.	Course No.	Title of the course	L	T	P	C
1.	MIS-NISCAIR-2-327	Data Base Management System	2	1	0	3
2.	MIS-NISCAIR-3-328	Environment and Environmental Impact Analyses	2	1	0	3
3.	MIS-NISCAIR-3-329	Glaciology	2	1	0	3
4.	MIS-NISCAIR-3-330	Climatology	2	1	0	3
5.	MIS-NISCAIR-3-331	Ecology, Remote sensing and GIS	2	1	0	3
6.	MIS-NISCAIR-3-332	Introductory oceanography	2	1	0	3
7.	MIS-NISCAIR-3-333	Environmental ocean technology	2	1	0	3
8.	MIS-NISCAIR-3-334	Ocean resources	2	1	0	3
9.	MIS-NISCAIR-3-335	Integrated coastal zone management	2	1	0	3
10.	MIS-NISCAIR-3-336	Oceans and climate change	2	1	0	3

Principal Faculties:

1. **Dr. P D Tyagi,**
2. **Dr. S C Sharma,**
3. **Dr. Majumdar,**
4. **Dr. Sanjay Sen Gupta,**
5. **Dr. Tarakanta Jana**
6. **Dr. G. Mahesh)**
7. **Dr. Rajeev Gupta,**
8. **Dr. R S Beniwal**
9. **Mrs. Charu Verma**
10. **Dr. Pankaj Gupta**
11. **Dr. Rajendran**
12. **Dr J Sundaresan**

Other than the above faculties the course will be supported by scientists from various CSIR, ISRO Institutes and faculties from IIT and universities who are associated with the collaborative projects developed by NISCAIR

NATIONAL INSTITUTE OF SCIENCE COMMUNICATION AND INFORMATION RESOURCES (CSIR-NISCAIR)

INSTITUTE PROFILE

NATIONAL INSTITUTE OF SCIENCE COMMUNICATION AND INFORMATION RESOURCES (NISCAIR) came into existence on 30 September 2002 with the merger of NATIONAL INSTITUTE OF SCIENCE COMMUNICATION (NISCOM) and INDIAN NATIONAL SCIENTIFIC DOCUMENTATION CENTRE (INSDOC). Both NISCOM and INSDOC, the two premier institutes of the COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), were devoted to dissemination and documentation of S&T information.

NISCOM had been in existence for the last six decades (first as two publication units of CSIR, which were merged to form the publications division, which was later renamed as publications & information directorate and in 1996, as NISCOM). over the years, NISCOM diversified its activities, and through a host of its information products, comprising research and popular science journals, encyclopaedic publications, monographs, books, and information services, it had been reaching out to researchers, students, entrepreneurs, industrialists, agriculturists, policy planners and also the common man.

INSDOC came into being in 1952 and was engaged in providing S&T information and documentation services through myriad activities such as abstracting and indexing, design and development of databases, translation, library automation, providing access to international information sources, human resource development, consultancy services in setting up modern library-cum-information centers. INSDOC was also host to the national science library and the SAARC DOCUMENTATION CENTRE.

Now, with the formation of NISCAIR, all the above multi-faceted activities have been amalgamated, making NISCAIR, an institute capable of serving the society using modern it infrastructure in a more effective manner and taking up new ventures in the field of science communication, dissemination and S&T information management systems and services. Broadly the core activity of NISCAIR will be to collect/store, publish and disseminate S&T information through a mix of traditional and modern means, which will benefit different segments of society.

INSTITUTIONAL MANDATE

To become the prime custodian of all information resources on current and traditional knowledge systems in science and technology in the country, and to promote communication in science to diverse constituents at all levels, using the most appropriate technologies.

- *To provide formal linkages of communication among the scientific community in the form of research journals in different areas of S&T*
- *To disseminate S&T information to general public, particularly school students, to*

inculcate interest in science among them

- *To collect, collate and disseminate information on plant, animal and mineral wealth of the country*
- *To harness information technology applications in information management with particular reference to science communication and modernizing libraries*
- *To act as a facilitator in furthering the economic, social, industrial, scientific and commercial development by providing timely access to relevant and accurate information*
- *To develop human resources in science communication, library, documentation and information science and S&T information management systems and services*
- *To collaborate with international institutions and organizations having objectives and goals similar to those of NISCAIR*
- *Any other activity in consonance with the mission statement of NISCAIR*

SPECTRUM OF ACTIVITIES

National Institute of Science Communication and Information Resources (NISCAIR) is devoted to science communication, dissemination and S&T information management systems and services using modern IT infrastructure. Broadly the core activity of NISCAIR is to collect/store, publish and disseminate S&T information through a mix of traditional and modern means, which benefits different segments of society.

The institute offers wide range of information services ranging from literature search to production and printing of S&T publications. The spectrums of activities covered by NISCAIR are

- *Human Resource Development: NISCAIR has been providing human resource development programs on information science for the last several decades.*
- *Projects: NISCAIR also undertakes projects on turnkey basis for other organizations. The projects cover design and development of databases, automation and modernization of libraries, editing and production of various publications like journals, books, conference proceedings, annual reports, etc. TKDL is one of the important projects where NISCAIR had shown excellence for digitizing traditional knowledges (i.e. Ayurveda, Unani, Siddha & Yoga) under modern IT environments.*
- *Knowledge Intensive Services – NISCAIR has started a National Prior Art Search Facility service for the benefits of ideators, inventors, scientists of national research facilities and science planners in order to provide high end services like prior art search, patent drafting and patent informatics.*
- *Editing - NISCAIR, with well-qualified and highly experienced editorial staff on its roll, provides editorial services for Conference Proceedings, Scholarly Books, Popular Science Books, etc. for other organizations on man-hour basis.*
- *Print and Production - NISCAIR is not only self-sufficient in composing/printing of its own publications including research journals, but also takes up similar specialized jobs of other CSIR laboratories/institutions, government agencies/departments and other organizations using the state-of-the-art technology.*

- *Graphic designing - NISCAIR has a full-fledged Art & Graphic Section with well-qualified and highly experienced staff and modern computer-based facilities like Photoshop, Corel Draw, etc.*
- *Desk Top Publishing, being the backbone of any publishing house, NISCAIR has a strong DTP unit with latest computers, scanners, printers and specialized manpower. It undertakes not only the publications of NISCAIR, but outside jobs too on payment basis.*
- *Literature search - NISCAIR offers literature search service and compile bibliographies on demand from indigenous as well as from international databases in the areas of S&T, engineering, industry etc*
- *Translation service - NISCAIR provides translation of S&T documents from 20 foreign languages into English. NISCAIR also provides reverse translation (English into foreign language) also.*

DEPARTMENTS/DIVISIONS

(A) PATENT INFORMATICS AND COMPUTATIONAL BIOLOGY

Computational Biology & Bioinformatics uses mathematical and computational approaches to address theoretical and experimental questions in biology. NISCAIR is conducting research in homology modeling, target discovery, molecular docking, and lead screening in drug discovery and database development. The availability of complete genome sequences of many industrially important microbes, disease causing pathogen and vast amount of structural information have stimulated many efforts to rationalize enzyme modeling and drug design. The 'omics' (genomics, proteomics, transcriptomics, metabolomics) together with informatics (patent informatics, bio-informatics/computational biology will speed up multidisciplinary research on enzyme modeling, structure-based drug design and epitope-driven vaccine design.

NISCAIR has instituted Patent Informatics & Computational Biology Division under III (Informatics & Informetrics Initiative) since some time now (a few years). It has, as part of new initiatives in an IT regime, through data mining of patent information (>4,000/- patents approx) by suggesting possibilities for more than one dozen new tubercular drugs under the internationally known CSIR Open Source Drug Discovery (OSDD) project, under the leadership of CSIR Director General. A large number of databases have been prepared for several other critical diseases like cancer, AIDS, leishmaniasis, clean energy, Sports technologies and Nutraceuticals etc. through patent analytics. Under an innovative concept of information driven innovation, SAARC Documentation Centre has awarded a project for SAARC countries to the division. The same division runs a National Prior Art Search Services facility, which enables an inventor to cross check his invention and its patentability. A large number of inventors are finding the facility immensely rewarding.

The division has embarked upon a lofty programme of educating technocrats about Intellectual Property Rights (IPR) which since long have been an arena of patent attorneys. The awareness gap on both sides was causing a lot of hardships and futile efforts causing resources drain. This crucial activity will result in faster intellectual throughput and techno-wealth generation, so much crucial for India today.

The division has accessed databases like Thomson Innovation index, Qpat, Delphion, DERWENT Innovation Index and software's like Accelrys Discovery studio 3.1, VLife's MDS etc. The division has also setup modern IT Laboratories. Considering the exciting new activity spectrum Computational Biology and Bioinformatics (CBB) has embarked upon, research and higher studies need to be regular activities. Therefore, various programmes under AcSIR are being suggested in subsequent paragraphs (see course details).

CLIMATE CHANGE INFORMATICS (CCI)

CCI is associated with impact of climate change for the last one decade. During the year 2009 U.T of Lakshadweep had sanctioned a project "Development of a Database for Climate Impact Studies in India – with special reference to Lakshadweep" to CCI of NISCAIR. Field data collection and analysis related to the above project are in progress. A specific method to estimate the land line recession and quantity of freshwater aquifer to be contaminated due to various scenarios of sea level rise for small coral islands were developed and the same had been published in International Journals.

NISCAIR had associated with various organizations to undertake climate change project in different ecosystems in the country. The Research Council of NISCAIR ha approved all the projects. The project entitled "Vulnerability Assessment and Development of Adaptation Strategies for Climate Change Impact with special reference to coasts and island ecosystems of India" (VACCIN) is a collaborative project and fourteen organizations viz. IIT, universities, CSIR Institutions are associated with it. Another project titled "Climate Change Database for Impact Assessment and Development: Adaptation and Mitigation Options for Kerala - A multi disciplinary simulation and modeling" is a collaborative program and more than fifteen organizations are associated with the project. The project titled "Climate Change Initiatives for Indian Himalayan Region (IHR) – with special reference to database, mitigation and adaptation" is a collaborative attempt with six CSIR Institutions. NISCAIR had specific facilities and tools related to Geospatial technology and climate change viz. ERDAS, Arc GIS and DGPS.

The National Level training program on Climate change and Geospatial technology was organized at NISCAIR during 12-18th March 2012. Fifteen trainees were selected for the Training program from various organizations. Dr Rob Roggema, REMIT, Melbourne (Australia), Dr Andrea Deri, University of London, U.K and Prof Ramesh Singh, University of Chapman, USA had given lectures. Another, International Conference on Climate Change and Environment was organized (ICCCE) as a part of the project "Development of a Database for Climate Impact Studies in India – with special reference to Lakshadweep". It was held at Cochin University of Science and Technology during 24-26 October 2010. Many scientists from abroad Prof. Herman A Karl, University of New Hampshire (USA), Dr Ram Boojh, UNESCO representative to SAARC countries were attended. Dr Clieve Representative from World Coral Network (Australia), Dr. Tomonori Matsuura, Toyama University (Japan) were presented papers in the Conference. In addition, The International Workshop on Climate Change and Island Vulnerability (IWCCI) was held on 28-31st October 2010 at Kadmat Island, U.T of Lakshadweep. Prof Fredolin Tangang, National University of Malaysia and Vice Chairman of Intergovernmental Panel for Climate Change, Dr. Ramboojh, Program Specialist, Ecological

and Earth Sciences, UNESCO Office for South Asia, Dr Leonard Sonnenschein, President, World Aquarium and Conservation for the Oceans Foundation had presented papers.

NISCAIR publishes Indian Journal of Marine Sciences since 1972, a bi-monthly journal this multi-disciplinary journal publishes full papers and short communications in the following areas: marine biology, marine chemistry, marine geology, physical oceanography, ocean engineering, marine instrumentation, marine corrosion and material science, satellite oceanography & modeling, marine engineering, marine pollution, marine archaeology, coastal zone management.

QUALITY STATEMENT FOR PHD STUDENTS

The indicators of quality, which are to be used for evaluating student ability and to build up their doctoral programs, will follow AcSIR guidelines.

(A) Ph.D (Engg. & Science) in Computational Biology & Bioinformatics (CBB)

1. Common Core (14 Credits)

Every Ph.D. student, irrespective of his/her background and the programme of study, has to fulfill the following requirements.

S.No.	Course No.	Course Title	L-T-P-C
01.	MIS-NISCAIR-1-311	Research Methodology	1-1-0-2
02.	MIS-NISCAIR-3-312	Advanced Self Study	0-2-4-4
03.	MIS-NISCAIR-4-313	Project Proposal Writing & Review Article	0-1-6-4
04.	MIS-NISCAIR-4-314	CSIR-800 Societal Program	0-0-8-4

2. Programme Electives (6 Credits)

Any of the following courses (depending on availability) may be chosen appropriately to fulfil the total credit requirements.

S.No.	Course No.	Course Title	L-T-P-C
01.	MIS-NISCAIR-2-315	Basic & Advance Bioinformatics	2-1-0-3
02.	MIS-NISCAIR-3-316	Languages Learning in Bioinformatics	2-1-0-3
03.	MIS-NISCAIR-3-317	Database Management Systems	2-1-0-3
04.	MIS-NISCAIR-3-318	Discovery & Translational Bioinformatics	2-1-0-3
05.	MIS-NISCAIR-3-319	Genomics, Metagenomics, Proteomics & Transcriptomics	2-1-0-3
06.	MIS-NISCAIR-3-320	Computational Biology Approaches for Drug Discovery/ Drug Discovery Informatics	2-1-0-3
07.	MIS-NISCAIR-3-321	Computational Immunology / Immunoinformatics	2-1-0-3
08.	MIS-NISCAIR-3-322	Computational Neurology/Neuroinformatics	2-1-0-3

(B) Ph.D (Engg. & Science) in Database systems & Climate Change Informatics (DBS & CCI)

COMMON CORE (14 CREDIT)

S.No.	Course No.	Title of the course	L	T	P	C
1.	MIS-NISCAIR-1-323	Research Methodology	1	1	0	2
2.	MIS-NISCAIR-3-324	Advance Self Studies	0	2	4	4
3.	MIS-NISCAIR-4-325	Project Proposal Writing & Review Article	0	1	6	4
4.	MIS-NISCAIR-4-326	CSIR-800 Societal Program	0	0	8	4

PROGRAMME ELECTIVES (6 CREDITS)

S.No.	Course No.	Title of the course	L	T	P	C
1.	MIS-NISCAIR-2-327	Data Base Management System	2	1	0	3
2.	MIS-NISCAIR-3-328	Environment and Environmental Impact Analyses	2	1	0	3
3.	MIS-NISCAIR-3-329	Glaciology	2	1	0	3
4.	MIS-NISCAIR-3-330	Climatology	2	1	0	3
5.	MIS-NISCAIR-3-331	Ecology, Remote sensing and GIS	2	1	0	3
6.	MIS-NISCAIR-3-332	Introductory oceanography	2	1	0	3
7.	MIS-NISCAIR-3-333	Environmental ocean technology	2	1	0	3
8.	MIS-NISCAIR-3-334	Ocean resources	2	1	0	3
9.	MIS-NISCAIR-3-335	Integrated coastal zone management	2	1	0	3
10.	MIS-NISCAIR-3-336	Oceans and climate change	2	1	0	3

COMMON CORE (COURSE DETAILS)

MIS-NISCAIR-1-311	**Research Methodology**	**1-1-0-2**

Course coordinators: Dr. Tarakanta Jana
(Faculty : Dr. Tarakanta Jana, Shri Hasan Javed khan & Shri S. C. Sharma)

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

Role & importance of science communication, effective oral and written communication, Technical report writing, research paper writing, dissertation/thesis writing, letter writing and official correspondence. Oral communications in meetings, seminars, group discussions; Use of modern tools for technical writing; Making technical presentation.

Recommended Books:

1. Craig Loehle: Becoming a Successful Scientist strategic thinking for scientific discovery, Cambridge University Press.
2. Blaxter, L., Hughes, C. and Tight, M. (2001) How to do research (2nd ed.), Buckingham, Open University Press.
3. Walliman, N. (2005) Your research project: a step-by-step guide for the first-time researcher (2nd ed.), London, Sage.

MIS-NISCAIR-3-312	**Advanced Self Study**	**0-1-6-4**

Course coordinators: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana & Dr. G. Mahesh)

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

MIS-NISCAIR-4-313	**Project Proposal Writing & Review Article**	**0-1-6-4**

Course coordinators: Dr. Tarakanta Jana

(Faculty: Dr. Tarakanta Jana & Dr. G. Mahesh)

Two subject proposals to be prepared before comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc.

(2 credits for one proposal)

Recommended Books:

1. Janice R. Matthews, Robert W. Matthews: Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences, Cambridge University Press.

MIS-NISCAIR-4-314	**CSIR-800 Societal Programme**	**0-0-8-4**

Course coordinators: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana & Dr. G. Mahesh)

The students have to undertake a project in rural area for 6-8 weeks in line CSIR-800 programme which is primarily prepared at the empowering 800 millions Indian by way of S&T inventions. The theme for the project may be chosen form CSIR -800 document and as per expertise available at the individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

(1 credit for two practical)

PROGRAMME ELECTIVES (COURSE DETAILS)

MIS-NISCAIR-2-315	**Basic & Advance Bioinformatics**	**2-1-0-3**

Course coordinator: Dr. Tarakanta Jana
(Faculty : Dr. Tarakanta Jana & Expert Faculty)

Course Description: Bioinformatics is amalgamation of biology, computer science, mathematics and information technology. Basic Bioinformatics comprises of gene analysis through its sequence, its structure prediction and similarity search. Advance Bioinformatics comprises Dynamics, simulation and algorithms related to genome, drug design and molecular modeling.

Topics:

- Protein sequence & Structure prediction, Modeling methods, Nucleic acid sequence and Structure prediction, Evolutionary models, Gene structure prediction in prokaryotes and eukaryotes, Image analysis and Biomedical applications.
- Genome sequencing, Microarray analysis, Reverse vaccinology and Immunoinformatics, Database in Immunology, Principles of B-cell and T-cell epitope prediction
- Macro-molecular force fields, Geometry optimization algorithms, Various simulation

techniques: Molecular mechanics, Conformational searches, Molecular Dynamics, Monte Carlo, Genetic algorithm approaches

- Rigid and Semi Flexible Molecular Docking, PMISum, Whatcheck, Procheck, Verify3D, ProsaII, Critical assessment of Structure prediction (CASP), Structures of oligomeric proteins, Study of interaction interfaces

Recommended Books:

1. David W Mount, Bioinformatics: Sequence and Genome Analysis, 2nd Edition, cold Spring Harbour Press.
2. Durbin et al (2007) Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids Cambridge University Press.
3. Thomas E. Creighton, Proteins: structures and molecular properties
4. Chemoinformatics Edited by Johann Gasteiger and Thomas Engel
5. Structural Bioinformatics, Edited Philip E. Bourne and Helge Weissig.

MIS-NISCAIR-3-316	**Languages Learning in Bioinformatics**	**2-1-0-3**

Course coordinators: Shri S.R. Kundu
(Faculty : Shri Mukesh Pund, Mrs. Charu Verma, Shri Sanjay Burde, Shri C.B. Singh & Dr. Tarakanta Jana)

Course Description: Language learning in Bioinformatics designed especially to making familiar with programming which has major role in development of software and databases in bioinformatics. Perl, Python, Ruby, XMK and MATLAB are included with intention to expert students even who have non-programming background.

Topics:

- PERL Introduction, Features, Scalar Variables, Array Variables, File Handling, Lists (Arrays), Hashes (Associative Arrays), Control Structures, String Processing, Subroutines
- PYTHON Introduction, Features, Python Interpreter, Control Flow Tools, Data Structures, Modules, Input and output, Errors and Exceptions, classes,
- RUBY Introduction, Features, General syntax rules, classes, objects, variables, Containers, Blocks, Iterators, Loops, Branching, Arrays, Hashes, Strings, Regular Expressions, Subroutines, Exceptions, Terminal IO, File IO
- XML Introduction, Need , The general structure of XML, XML Tags, Elements and sub elements, XML documents, XML attributes, Well formed XML documents, Valid XML documents, XML DTD

- MATLAB Introduction, The basic features, Vectors and matrices, Built-in functions, Plotting, Programming in MATLAB, M-files: Scripts and functions, Loops, Polynomials in MATLAB, Numerical Methods

Recommended Books:

1. 'Programming Ruby The Pragmatic Programmers' Guide Second Edition Dave Thomas with Chad Fowler and Andy Hunt, The Pragmatic Bookshelf
2. Beginning Python, Peter Nortan, Wiley Publishing, Inc.

MIS-NISCAIR-3-317	**Database Management Systems**	**2-1-0-3**

Course coordinators: Shri S.R. Kundu
(Faculty : Shri Mukesh Pund, Mrs. Charu Verma, Shri Sanjay Burde, Shri C.B. Singh & Dr. Tarakanta Jana)

Course Description: Database Management Systems is almost completely related to Information Technology. It is very helpful for biology background students for better understanding of framework of database. It controls creation, maintenance and use of database. This course enables students to work with databases independently and facilities for controlling data access, enforcing data integrity, managing concurrency control, and recovering the database after failures and restoring it from backup files, as well as maintaining database security.

Topics:

- Database system concepts, Database system architecture, ER data model, Relational data model, Relational algebra
- Tuple relational calculus, SQL, ER relational data model mapping, Indices, Relational algebra operation implementations
- Query optimization, Transaction management, Serializability theory, Concurrency, Control algorithms, Recovery
- Database security, Object oriented models, Object oriented databases, Data warehousing

Recommended Books:

1. Elmasri & Navathe, Fundamentals of Database Systems, Addison Wesley, 2000, Raghu ramakrishnan DBMS, Korth, Silberstaz & Sudarshan DBMS.

MIS-NISCAIR-3-318	**Discovery & Translational Bioinformatics**	**2-1-0-3**

Course coordinator: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana & Expert Faculty)

Course Description: 'Discovery Informatics' is the application of the appropriate computer science, information science and statistical tools in conjunction with domain specific scientific/engineering expertise to extract knowledge from data. New techniques and theories have been developed to address the need of diverse disciplines to obtain information from large multidimensional datasets, data streams, or complex systems.

Translational Bioinformatics is a field of science in which biology, computer science, and information technology merge into a single discipline to analyze biological information using computers and statistical techniques. The use of computers in solving information problems in the life sciences. It mainly involves the creation of extensive electronic databases on genomes, protein sequences etc. Also involves techniques such as three-dimensional modeling of bio-molecules and biological systems. Translational Bioinformatics is the assembly of data from genomic analysis into accessible forms. The biomedical world is so complicated (e.g., protein structural analysis, polymer conformational analysis, to name a few) and the exact structures of high molecular weight to find. It involves the application of information technology to analyze and manage large data sets resulting from gene sequencing or related techniques. The big discipline of Bioinformatics where the usage to run large programs which carry out tests for identifying drug candidates. The general science of bioinformatics is essentially it.

Topics:

- Introduction to discovery Informatics, Design and development of drug discovery databases, Development of analytical tools & software, Access and utility of publicly available data sources.
- Introduction to design of drug discovery database, Types of genome-scale measurements in molecular biology and genomic medicine, Analysis of microarray data, Cloud computing & clustering, Analysis of polymorphisms
- Proteomics, Protein interactions, Linking genome-scale data to clinical data and phenotypes, New questions in biomedicine using bioinformatics & Case studies, Database integration
- Introduction to clinical bioinformatics, Analysis of metabolic networks, Pathway analysis for drug design, Data mining, Molecular text mining, Molecular diagnosis, visualization and animation, Models for metabolic network analysis, Integrative microarray analysis, Gene networks for understanding disease

Recommended Books:

1. Discovery Informatics: Encyclopaedia of Data Warehousing and Mining, William W. Agresti (Johns Hopkins University, USA) ISBN13: 9781591405573, ISBN10: 1591405572 , EISBN13: 9781591405597
2. Translational Bioinformatics (Chapman & Hall/CRC Mathematical & Computational Biology)[Hardcover] Jake Y. Chen (Editor), Marciel G. Kann (Editor)

MIS-NISCAIR-3-319	**Genomics, Metagenomics, Proteomics & Transcriptomics**	**2-1-0-3**

Course coordinator: Dr. Tarakanta Jana
(Faculty : Dr. Tarakanta Jana & Expert Faculty)

Course Description: Genomics, Metagenomics, Proteomics & Transcriptomics are major form of Bioinformatics. From gene sequences to genome fragment assembly, to comparative genomics, to mapping gene, to building phylogenetic trees and analyzing microarray data, it would not be an exaggeration to state that computational biology is integral part of Bioinformatics. This course aid application and approaches of bioinformatics to molecular biology and increases strength to research and development.

Topics

- Structure & organization of Prokaryotic and eukaryotic genome, Mitochondrial & chloroplast genome, Gene structure, SNP's, Protein coding genes, repeated sequences, Computational approaches in comparative genomics
- Genome information resources, Brief outlooks of various genome projects and their outcome, Genome rearrangements, the breakpoint graph, expected reversal distance, Algorithm for sorting by reversals, Duality theorem and genomic distance, Genome annotation, Restriction mapping
- Polymerase chain reaction – principle, design of primers, RT-PCR, Multiplex PCR, Anchored PCR, Inverse-PCR and PCR walking, Molecular markers – 16S rDNA, RFLP, RAPD, AFLP, Repetitive extragenic palindromic (rep), Interspersed transcribed sequences (ITS)
- Metagenomics- concepts, methodology, softwares, applications, Biodiversity Informatics – Introduction, Introduction to phylogenetic trees, Relationship of Phylogenetic analysis to sequence alignment, Unweighted pair group method with arithmetic mean (UPGMA), Evaluation of phylogenetic methods,
- Transcriptomics- importance of transcription, tools and techniques in Transcriptomics,

Microarray technology, Sequencing based approaches to study transcriptomes, Applications of new generation transcriptome sequencing, Gene expression profiling, Non coding RNA discovery and detection.

Recommended Books:

1. Genes and genomes by Singer.M, and Berg.P, Blackwell Scientific Publication, Oxford ,1991
2. Gene Structure and Transcription by Beebe.T, and Burke.T, Oxford Univ Press.
3. Bioinformatics – A practical guide to the analysis of Genes and Proteins – Baxevanis and Fancis Ouellette, Wiley Interscience, New York.
4. Metagenomics: Theory, methods and applications, edited by Diana Marco , Caister Academic Press.
5. Computational Molecular Biology – An algorithmic approach – Pavel A. Pevzner
6. Developmental Biology, 6th Edition, Scott F. Gilbert.
7. Genes to clone by T. A. Brown
8. Genetic engineering by S. Mitra
9. Principles of Gene Manipulation: An Introduction to Genetic Engineering by Old RW and Primrose SB. Blackwell Science Publications.

MIS-NISCAIR-3-320	**Computational Biology Approaches for Drug Discovery/ Drug Discovery Informatics**	**2-1-0-3**

Course coordinators: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana, Dr. Vijayalakshmi & Expert Faculty)

Course Description: Computational biology approaches for Drug Discovery is advance level course enabling use of chemical libraries, manipulating chemical structures in various software, drug design and development, pharmacokinetic principles, CADD tools and combinatorial chemistry.

Topics

- Introduction to cheminformatics, history of cheminformatics, applications of cheminformatics, Evolution of cheminformatics, Future scope of cheminformatics
- Data and data source in chemistry, searching chemical structures, Representation of chemical compounds, Manipulations in 2D and 3D structures of chemical compounds and proteins, Representation of chemical reactions, Molecular descriptors, Calculations of physical and chemical data, Calculations of structural desiphers.
- Development of drug, Drug life cycle, Drug development time lines, Stages of drug

discovery, Strategic issues in drug discovery, Emerging approaches to drug design and discovery, Drug metabolism physic chemical properties, Pharmacokinetic action of drug on human body, Computer aided drug design, Methods of computer aided drug design

- Homology modeling, Structure and Ligand design methods, Docking algorithms and programs, Drug design approaches, Strategy for target identification and validation, Lead compound identification and optimization.
- Combinatorial chemistry and library design, Virtual screening, Drug likeliness and compound filters, Absorption, Distribution, Metabolism, Excretion and toxicity (ADMET) property prediction, Computer based tools for drug design.

Recommended Books:

1. Introduction to Chemoinformatics by Andrew R. Leach, Valerie J. Gillet
2. Introduction to Computational Chemistry by Frank Jensen
3. Targeted and Controlled Drug Discovery - S.P.VYAS and R.K.Khar
4. Cheminformatics By Johann Gasteiger and Thomas Engel
5. Bioinformatics from Genome to Drug By Thomas Langauer

MIS-NISCAIR-3-321	Computational Immunology / Immunoinformatics	2-1-0-3

Course coordinator: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana & Expert Faculty)

Course Description: The complete genome sequences of more than 180 organisms since 1995 of which majority of them are pathogenic microbes. Concurrently, a series of new informatics tools, designed to harness this new wealth of information, have been developed. Some of these new tools allow researchers to select regions of microbial genomes that trigger immune responses. These regions, termed epitopes, are ideal components of vaccines. When the new tools are used to search for epitopes, this search is usually coupled with in vitro screening methods; an approach that has been termed computational immunology or immuno-informatics. Computational immunology is an emerging field of science that encompasses high-throughput genomic and bioinformatics approaches to immunology. Computational methods are integral to virtually every research and development project in every discipline. Immunology is not an exception and the need for sophisticated computational method for research and development in immunology is increasing. At the same time, because of the extreme domain complexity of immunology, the lag between availability of sophisticated computational methods and their implementation in this field is increasing.

Researchers are now implementing these combined methods to scan genomic sequences for vaccine components. They are thereby expanding the number of different proteins that can be screened for vaccine development, while narrowing this search to those regions of the proteins that are extremely likely to induce an immune response. As the tools improve, it may soon be feasible to skip over many of the *in vitro* screening steps, moving directly from genome sequence to vaccine design. This course describes theoretical advances and practical applications of high throughput tools to the process of vaccine discovery.

Topics

- Introduction to immunology, antibody and antigens, Structural Immunoinformatics, Epitope analysis, Epitope prediction
- Analysis of MHC-peptide binding, Prediction of MHC-peptide binding, Databases for Immunoinformatics, Ontologies for Immunoinformatics
- Computational modeling of immune system, Analysis of minor histocompatibility antigens, prediction of minor histocompatibility antigens. Predictive models on organ transplantation
- Immunogenomics, Vaccine design, Artificial immune systems, Other biologically-inspired paradigms, Multi-agent based models of immunity, Gene networks, Systems biology in immunity, Allergenicity prediction.

Recommended Books:

1. Immunoinformatics Series: Immunomics Reviews:, Vol. 1 Schönbach, Christian; Ranganathan, Shoba; Brusic, Vladimir (Eds.) 2008
2. Immunoinformatics: Predicting Immunogenicity *In Silico* (Methods in Molecular Biology) by Darren R. Flower (Nov 19, 2010)
3. Immunoinformatics: Bioinformatic Strategies for Better Understanding of Immune Function (Novartis Foundation Symposia) by Novartis Foundation (Dec 8, 2003)

MIS-NISCAIR-3-322	**Computational Neurology/ Neuroinformatics**	**2-1-0-3**

Course coordinator: Dr. Tarakanta Jana
(Faculty: Dr. Tarakanta Jana & Expert Faculty)

Course Description: Neuroinformatics is a research field concerned with the organization of neuroscience data by the application of computational models and analytical tools. These areas of research are important for the integration and analysis of increasingly large-volume, high-dimensional, and fine-grain experimental data. Neuroinformaticians provide computational

tools, mathematical models, and create interoperable databases for clinicians and research scientists.

Topics

- Introduction to Neuroinformatics, Neuronal reconstructions : from image stacks to digital vector traces, ImageJ, Neuron Morphoplug-in, Neuromantic, V3D, Neuronland, CVAPP, Neuronal reconstructions: morphometric analysis and data mining, L-Measure, neuroConstruct.
- Neuroscience bioinformatics: BLAST, Swissprot, microarrays, Allen Brain Atlas, Introduction to Linux & LaTeX, Neuroinformatic Databases, Stereological measurement and online digital libraries, NIH ImageJ and the Mouse Brain Library, Quantitative Trait Loci, from Phenotype to Genotype
- WebQTL, SNP filtering, from QTL to Gene, Celera Discovery System, MCI database and NCBI LocusLink, QTL analysis, Single nucleotide polymorphisms
- Introducing Perl, to search for similarities between genomes, Perl and NCBI LocusLink, Realstic Neuronal Models of Pyramidal and Stellate Cells, Neuron and ModelDB, Cortical neurons

Recommended Books:

1. Neuroinformatics, G.A. Ascoli; E. de Schutter; D.N. Kennedy, Springer, ISSN: 1539-2791
2. Neuroinformatics (Methods in Molecular Biology) by Chiquito J. Crasto and S.H. Koslow (2007)
3. Databasing the Brain: From Data to Knowledge (Neuroinformatics) by Steven H. Koslow and Shankar Subramaniam (2005)
4. Computing the Brain: A Guide to Neuroinformatics by Michael A. Arbib (2001)

(B) Ph.D (Engg. & Science) in Database Systems & Climate Change Informatics (DBS & CCI)

COMMON CORE (COURSE DETAILS)

MIS-NISCAIR-1-323	**Research Methodology**	**1-1-0-2**

Course coordinators: Dr. Sundaresan J
(Faculty: Dr. P D Tyagi, Dr. S C Sharma, Dr. Majumdar, Dr. Sanjay Sen Gupta, & External experts)

- **Introduction**

  Meaning and Objective of Researcher, Steps in Research: Identification, selection and formulation of research problem. Review of literature, Hypothesis: meaning, Characteristics and importance of hypothesis in research, Problems in formulating hypothesis, testing of hypothesis, Sampling Technique: Sampling theory-Types of sampling-Steps in sampling, sampling and Non-sampling error-Sample size, Advantages and limitations of sampling

- **Research modelling**

  Research Modelling: Types of Models, Model building and stages, Data consideration and testing, Heuristic and Simulation modelling. Data for Research: Primary data-Meaning-Collection methods. Observation: Interview-Questionnaire. Schedule-Pre-test-Pilot study–Experimental and case studies-Secondary data- Meaning–Relevance, limitations and cautions. Processing Data: Checking- Editing-Coding- transcriptions and Tabulation- Data analysis- Meaning and methods- Quantitative and Qualitative analysis.

- **Statistical Techniques**

  Statistics in Research: Specific applications of measures of Central tendency, Dispersion, Skewness and Kurtosis in research. Measures of Relationship: Correlation – Simple, Partial and multiple- Regression- Simple and multiple-Association of Attributes – applications in research. Hypothesis Testing and estimation, Standard error point, and interval estimates-Important non-parametric tests. Parametric Tests: Testing of significance mean, proportion, variance and correlation-Testing for significance of difference between means, proportions, variances and correlation coefficients. ANOVA and Chi-Square Tests: One-way and two-way ANOVA – Latin Square tests for association and goodness of fit. Measurement in Research: Measurement scales – Tests of good measurement construction of Likert and Semantic Differential scales-Source of errors in measurement- Scale validation.

- **Research Report**

  Structuring the Report: Chapter format- Pagination- Identification- Using: quotations- Presenting footnotes – abbreviations- Presentation of tables and figures-Referencing- Documentation-Use and format of appendices- Indexing. Research Report: Types of reports-Contents-Styles of reporting- Steps in drafting, reports-Editing the final draft- Evaluating the final draft.

MIS-NISCAIR-3-324	**Advanced Self Study**	**LTPC: 0-1-6-4**

Course coordinators: Dr. Sundaresan J
(Faculty: Dr. Tarakanta Jana & Dr. G. Mahesh)

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

MIS-NISCAIR-4-325	**Project Proposal Writing & Review Article**	**0-1-6-4**

Course coordinators: Dr. Sundaresan J
(Faculty: Dr. Rajeev Gupta, Dr. R S Beniwal, Dr. S. C Sharma, Dr. Sanjay Sen Gupta)

Two subject proposals to be prepared before comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc.

(2 credits for one proposal)

MIS-NISCAIR-4-326	**CSIR-800 Societal Programme**	**0-0-8-4**

Course coordinators: Dr. Sundaresan J
(Faculty: Dr. Majumdar, Dr. Sanjay Sen Gupta, Dr. Rajeev Gupta & Dr. Mahesh)

The students have to undertake a project in rural area for 6-8 weeks in line CSIR-800 programme which is primarily prepared at the empowering 800 millions Indian by way of S&T inventions. The theme for the project may be chosen form CSIR -800 document and as per expertise available at the individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

PROGRAMME ELECTIVES (COURSE DETAILS)

MIS-NISCAIR-2-327	**Data Base Management System**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Rajeev Gupta, Dr. G Mahesh & Charu Verma and external expert)

Introduction

Introduction- Purpose of Database Systems, Views of data, Data Models, Database language, Transaction Management, Storage Management, Database Administrator, Database Users,

Overall System Structure, Different types of Database Systems

Data Model

E-R Model: Basic Concepts, Design Issues, Mapping Constraints, Keys, E-R Diagram, Weak Entity set, Extended E-R features, Design Of an E-R Database Schema, Reduction of an E-R schema to Tables. Relational Model: Structure of Relational Database, The Relational Algebra, The tuple relational calculus, The Domain Relational Calculus, Views. SQL- Background, Basic Structure, SET operations, Aggregate functions, Null. Values, Nested Sub queries, Derived Relations, Views, Modification of Database, Joined Relations, DDL, Other SQL features

Data Transaction and Concurrency Control

Transaction- Transaction Concepts, State, Implementations of Atomicity and durability, Concurrent Executions, Serializability, Recoverability, Transaction Definition in SQL. Concurrency Control- Lock based protocol, Timestamp based protocol, Validation, based protocol, Multiple Granularity, Multi version Schemes, Deadlock Handing, Insert and Delete operations, Concurrency in index structure, Query Optimization.

RDBMS and Others

Relational Database Design- Pitfalls in Relational-Database Design, Decomposition, Normalization , Using Functional Dependencies, and Normalization Using Multi valued Dependencies, Normalization Using Join Dependencies, Domain-Key Normal Form and Alternative Approaches to Database Design, Other Relevant Advance Topics and Applications- Object Oriented Database,Decision-Support Systems, Data Analysis, Data Mining, Data Warehousing, Spatial and Geographic Databases, Multimedia Databases, Mobility and Personal Databases, Information-Retrieval Systems, Distributed Information Systems, The World Wide Web.

Recommended Books:

MIS-NISCAIR-3-328	**Environment and EIA**	**2-1-0-3**
Course coordinator: Dr. Sundaresan J **(Faculty: Dr.P D Tyagi, Dr. S C Sharma, Dr. Sanajay Sen Gupta)**		

Environment

Holistic Environment- physical, chemical, biological components, socio-economic and cultural dimensions of environment, concepts of carrying capacity and global commons, Human activities and impacts: local, regional and global; short-term and long-term impacts on Environment.

Environment Impact Assessment

Origin and development of EIA, National environmental policy and statutory requirements of EIA; objectives of EIA.

EIA Analysis

Methodology of EIA; scoping, categorization and evaluation criteria; prediction and assessment of impact, interactions between environmental components and impacts. Alternate strategies and mitigation measures, environmental monitoring and audit.

Case Studies

Urban development, water resources development, Oceanographic, Glaciers studies, Impacts on critical habitats-Marine and Terrestrial.

Recommended Books:

Introduction to Environmental Science by Eric Pallant and Terrence Bensel.

Environmental Impact Assessment: A Practical Guide by Betty Marriott.

Introduction to environmental impact assessment by John Glasson, Riki Therivel, Andrew Chadwick

MIS-NISCAIR-3-329	**Glaciology**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Pankaj Gupta and External Expert)

Introduction

Glacier, importance and implication of glaciological studies, Cryosphere, inventory of himalayan glaciers, identification system of glaciers,

Glacial Geomorphology

Glacial geomorphology, glacial deposits and paleoglaciation, hydrometry glaciated basins, suspended sediment transport, mass balance studies- net balance, ablation measurement, accumulation measurement, snow density measurement, relationship of mass balance to climate, snow melt processes

Glacial Physics

Physics of ice and snow, mechanics of snow/ice creep, ice crystals, engineering properties of glacial materials, glacial hydrochemistry

Satellite glaciology

Application of remote sensing techniques in glaciology, application of advance surveying techniques, global positioning system, geodetic techniques.

Recommended Books:

1. Physics of Glaciers, Third Edition W. S. B. Paterson.
2. Glaciology Introduction :Non-Polar Ice Cap, Glaciers of Bhutan, Farm Creek Section, Glacial Lake, AR Te, Wedgwood Rock, Glacier Morphology

MIS-NISCAIR-3-330	**Climatology**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Rajendran, Dr. Sanjay Sen Gupta & External experts)

- **Introduction**

  Definition of weather and climate; climatology origin, composition and structure of atmosphere. solar radiation, heat budget and temperature distribution. atmospheric pressure and its distribution pattern.

- **Atmospheric Circulation**

  General circulation and planetary winds, walker circulation- enso and la nina, origin of monsoons and jet streams. Atmospheric moisture: humidity, evaporation, condensation. precipitation: dynamics and types of precipitation. Stability and instabilityof atmosphere, air masses and fronts. air masses and fronts. Weather systems: extra tropical and tropical cyclones.

- **Climate Classification and Modelling**

  climatic classification: basis of climatic classification by koeppen, trewartha and thornthwaites. climatic changes- evidences and explanations. global warming and its impacts. mitigation and adaptation. Climate Modeling Introduction to basic equations for the atmosphere. Brief overview of hierarchy of models. Numerical methods: finite difference, spectral and semi-Lagrangian techniques. Model physics: parameterization of subgrid-scale phenomena such as cloud-convection, land- surface processes, boundary-layer effects and radiation. Introduction to coupling with ocean models

- **Satellite Meterology**

  Satellite Meteorology Introduction to radiative transfer; radiative properties of surface; radiative properties of the atmosphere; scattering of radiation; image analysis; thermal, infrared and microwave techniques for measurement of temperature, humidity and cloud height; atmospheric sounders, limb sounding, radiation budget.

Recommended Books:

1. Introduction to climate dynamics and climate modeling Goosse H., P.Y. Barriat, W. Lefebvre, M.F. Loutre and V. Zunz, (date of view).
2. Introduction to climatology for the tropics by J. O. Ayoade

MIS-NISCAIR-3-331	**Ecology, Remote sensing and GIS**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty:DR J Sundaresan, Dr R.S Benniwal & Dr. Panksj Gupta,)

- **Ecology and Ecosystem Based Management**

Introduction, Concepts, Life processes and adaptations, Distribution and abundance of organisms, the movement of materials and energy through living communities, Ecosystem based management, EBM Tools. The successional development of ecosystems, and the abundance and distribution of biodiversity in context of the environment. Bio geographic classification- Bio geographic zone, Province, Region and Biome,

- **Remote Sensing**
  Introduction, Basics of Remote Sensing, and Aerial Photography. Electro Magnetic Spectrum, Law of Radiation, Atmospheric interaction, Remote Sensing System, Spectral Reflectance, Resolution, Orbit and Platform, Remote Sensing Satellites, Principle of Thermal and Microwave imaging. Visual Image Interpretation, Image Processing, Image Classification, Remote Sensing Application
- **Geographical Information System**
  GIS, Coordinate System and Projections, Spatial Analyst, Geo-statistical Analysis, Spatial Statistics, Geo-Data Base, DGPS-GIS Applications.

Recommended Books:

1. Science of Ecosystem-based Management: Narragansett Bay in the 21st Century
2. Alan Desbonnet, Barry A.
3. Remote Sensing of the Environment and Earth Resource Perspective
4. John R. R. Jensen
5. An Introductory Digital Image Processing: A Remote Sensing Perspective
6. John R. Jensen
7. Computer Processing of Remotely Sensed Images: An Introduction Paul M. Mather,Paul Mather
8. Laser Remote Sensing of the Ocean : Methods and Applications Konstantin I. Voliak,Alexey F. Bunkin
9. Remote Sensing and Image InterpretationThomas M. Lillesand,Ralph W. Kiefer
10. Extensively illustrated, this updated edition provides a balance between classical visual image interpretation and digital image processing techniques.
11. GIS: A Visual Approach. Bruce Ellsworth Davis,Bruce Davis

MIS-NISCAIR-3-332	**Introductory Oceanography**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr.Sundaresan J and Dr Rajendran)

- General introduction – history of oceanography – expeditions - geomorphology and structures of the ocean floor, Continental slope and shelf - physical properties of sea water- distribution, of temperature, salinity, density and oxygen in space and time - acoustical and optical characteristics of seawater – color of the sea. Ocean waves and tides. Significant wave height and period, wave spectrum, principles of wave forecasting

- wave data and measurement techniques.

- Water masses: formation and classification - T-S diagram – water masses of the world oceans – Indian Ocean water masses - identification of water masses. Circulation: general circulation of the atmosphere — Ekman spiral – wind-driven circulation - currents in the oceans – upwelling - thermohaline circulation - El-Nino and La-Nina.
- Heat budget of ocean: insolation – long wave radiation – effect of clouds – sensible and latent heat transfer- Bowen's ratio – ocean heat transport – spatio - temporal variability of heat budget terms and net heat balance.

Recommended Books:

1. Descriptive Physical Oceanography: G.L.Pickard and W. J. Emery, Pergamon, 5th edn., 1992.
2. Descriptive Physical Oceanography: M.P.M.Reddy, Balkema, 1st edn., 2001.
3. The Oceans: H.U. Sverdrup, Prentice Hall, 1st edn., 1942
4. Principles of Physical Oceanography: G.Neumann & WJ Pierson, Jr., Prentice Hall,1st edn.,1966.
5. Encyclopedia of Oceanography: Fairbridge, Reinhold, 1st edn., 1979.
6. Physical Oceanography Vol.I & II: A Defant, Pergamon Press, 1st edn., 1961.
7. Ocean Currents: G. Neumann, Elsevier, 1st edn., 1968.
8. Regional Oceanography: Tomczak M. & J.S.Godfrey,
9. Ocean Circulation & Climate: Siedler, Church & Gould, Academic Press, 1st edn., 2001.
10. Foundations of Fluid Mechanics: S.W.Yuan, Prentice-Hall, 1st edn., 1970
11. Physical Fluid Mechanics : D.J. Tritton, Oxford Science Pub., 2nd edn., 1978.
12. Fluid Mechanics : W. Kaufman, Wiley, 1st edn., 1954.
13. Geophysical Fluid Dynamics : J. Pedlosky, Springer Verlag, 2nd edn., 1982.
14. Fundamentals of Acoustics: L.E.Kinsler and A.R.Frey, John Wiley, 3rd edn., 1982.
15. Ocean Acoustics : Tolstoy and Clay, McGraw Hill, 1ste dn., 1966.

MIS-NISCAIR-3-333	**Environmental Ocean Technology**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Sundaresan J and External experts)

- Pollution of air, soil and water: Causes of pollution. Common pollutants- solid waste, liquid waste and gaseous wastes. Fate of various pollutants. Pollution of marine environment. Standards for natural, inland and marine waters. Technological Control measures- Design of control systems - EIA studies.

- Marine corrosion: Fundamental factors affecting corrosion of metals in water. Marine Environmental aspects - different forms of corrosion – pitting, bimetallic (galvanic) corrosion, and deposit attack. Design of corrosion control devices – practical field considerations - anticorrosive and antifouling technology.
- Energy from the sea: Waves, tide, OTEC, Osmosis, Solar and wind energy systems. Operational aspects and oceanographic factors, new technologies, design and applications, case studies.
- Marine Information systems: Data management and dissemination of information, feedback and updating mechanisms. Marine surveillance. Law of the sea. Current legislation on the exploitation of the ocean resources, the maritime zones, territorial zones, EEZ, Sea Bed Authority, legal principles for conduct of marine scientific research.

Recommended Books:

1. Advances in Water Pollution Research: B.A.Southgate, Proc. London, 1962.
2. Remote sensing for the Control of Marine Pollution Vol6: Jean Marie Massin, NATO, 1984.
3. Marine Environmental Pollution 2: Richard A, Geyer, Elsevier, 2nd edn., 1999.
4. Marine and Off shore Corrosion: Kenneth A Chandler, Butterworth, London, 1st edn., 1985.
5. Corrosion Engg. : Fontana & Greene, Tata McGraw Hill, 3rd edn., 1998.
6. Hand book of Oceanographic Engg.Materials: Stephen G. Dexter, Wiley, 1st edn., 1979.
7. Cathodic Protection, Theory andPractice: V. Ashworth & C.J.L. Booker, Ellis Harwood, 1st edn., 1986.
8. Corrosion in Marine Environment: D.H.Deere, John Wiley, 1st edn., 1977.
9. Bio-deterioration of Materials: A. Harry Walters and John J, Elsevier, 1st edn., 1968.
10. Metals hand book, American Society for Metals :International Metals Park, Uty Michigan, 1st edn., 1987.
11. Ocean Wave Energy Conversion :Michael E. Mc Cormick, Wiley, 1st edn., 1981.
12. Wave Energy - a Design Challenge :R.Shaw, Halsted Press, 1st edn., 1982.
13. Tidal Power :Institution of Civil Engineers, U.K, Plenum, 1st edn., 1972.
14. Ocean Engg. - Goals,Environmental Technology :J.F. Brahtz, Wiley, 1st edn., 1968.

MIS-NISCAIR-3-334	**OCEAN RESOURCES**	**2-1-0-3**
Course coordinator: Dr. Sundaresan J **(Faculty: Dr. Sundaresan J and Dr Pankaj Gupta)**		

- Ocean Resources: definition and classification, potential uses of sea. Geophysical and oceanographic operations: direct and indirect methods of data collection on and below sea surface, Involvement of ocean scientists in exploration and exploitation, phases of marine resources.
- Operational requirements, ports and harbors, vehicle requirements, planning and policy on ocean resources, harvesting food from the sea, extracting or dredging raw materials, sea as a highway, energy generation, military exercises, leisure and tourism, sewage and waste disposal.
- Understanding the hostile marine environments, mineral and hydrocarbon resources, exploration, development, and production of hydrocarbons, ocean mining, semi-submersible and their functions, stability, motion and weight.
- The ice environment and operations in extreme weather conditions, offshore safety and rescue. Use of marine robotics and expert systems, machine based operations for solving strategic resource issues.

Recommended Books:

1. The Oceans, Our future: M Soares, Cambridge Univ. Press, 1978.
2. Oceanology Vol. 6: Soc. Underwater Technology, Graham & Trotman, 1988.
3. Descriptive Physical Oceanography: W J Pierson and G Neumann, Pergamon, 5th edn., 1990.
4. Mining Engineers Handbook, Vol. 2 :Teele, John Wiley, 2nd edn., 1996.
5. Introduction to mineral Exploitation :Antony M Evans, Wiley, 3rd edn., 1990.
6. Coastal and Deep Ocean Dredging :John B Herbich, Gulf Pub. 1st edn., 1975.
7. The Sustainable Management of
8. Tropical Catchments :Harper & Brown, Wiley 1st edn., 1999.
9. The Ocean Basins and Margins :Dercourt, Plenum, Vol.8, 1996.
10. Introduction to Energy Resources,
11. Technology and Society :E S Cassdy, Elsevier, 1st edn., 2000.
12. Underwater Minerals : D S Cronon, Academic Press, 1st edn., 1980.
13. Ocean Year Book (Vol 1 – 4) : Borges & Ginsburg, The University of Chicago Press, 1983.
14. Mineral Wealth of the Ocean : Ghosh & Mukhopadyay, Oxford & IBH Pub. Co., 2nd, 1999.

MIS-NISCAIR-3-335	**Integrated Coastal Zone Management**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Sundaresan J)

- Coastal zone management – concepts, definition and techniques. Approach to CZM. Nature of coastal zones of the world. Development and Conservation activities. Resource management of coastal regions.
- Matrix on CZM. Systems approach. Balanced budget on use and preservation of resources of the coastal zone. Coastal ocean processes and CZM. Coastal features and marine influence on coastal development.
- Acts and legislation on CZM. Implementation of policies. Traditional practices, values and emerging modern technological innovation. Case studies.
- Planning and developmental approaches in CZM. Current practices and Future outlook. Coastal vulnerability. Methods for evaluation of coastal status. Sustainable development of coastal zone.

Recommended Books:

1. CZM : Brathz Ecosystems at the Land Sea Margins – Drainage Basin to Coastal Seas : Thomas, Smodlaka & Turner, AGU, 1st edn., 1999.
2. Large Scale Constructions in Coastal Environments : Vollmer and Grann, Springer Verlag, 1st edn., 1998.
3. Fluvial Process and Environmental change: Brown, John Wiley, 1st edn., 1999.
4. Coastal Erosion – Response and Management : Charlier and Meyer, Springer Verlag, 1st edn., 1998.
5. Mixing in Estuaries and Coastal Seas : Pattiaratchi, AGU, 1996.
6. Coastal Zone Management -Coastal Management : Salomons, Springer, 1st edn., 2001.
7. Coastal Zone Management (2 Vol.) : Korakandy Kalpaz Publications, 1st edn., 2005
8. Gis For Coastal Zone Management : Bartlett Darius, CRC Press, 1st edn., 2003.
9. Introduction -Coastal Zone Management : Beatley Timothy, Island Press, 1st edn., 2002.
10. ICZM for Coral Reefs: Decision Support Modeling : Gustavson, Huber, Ruitenbeek, World Bank Pub., 1999.
11. Integrated Coastal Zone Management (ICZM) The Global Challenge : R R Krishnamurthy, Research Pub. Services, 2002.
12. Coastal Planning and Management: Robert Kay, Taylor & Francis, 2nd edn., 2005

MIS-NISCAIR-3-336	**Oceans and Climate Change**	**2-1-0-3**

Course coordinator: Dr. Sundaresan J
(Faculty: Dr. Sundaresan J, Dr. Rajendran)

- Role of oceans in climate - Indicators of climate change – short and long term observations – IPCC and results – Forecast and Predictions – Study on parameters related to climate change.
- Signals from study of Temperature, global warming, role of carbon-di-oxide content and related gases, sea level changes.
- SST and precipitation features, weather conditions and marine ecosystems – ongoing projects in climate change studies.
- The ocean conveyor belt – influence on circulation patterns – The Carbon cycle – responses from ecological systems – Impacts - Human interventions – Robust findings and key uncertainties.

References:

1. Climate Change 1992 : Report – IPCC, J T Houghton, C A, Callander & S K Varney
2. Climate Change 2001, 2008 : Synthesis Report – IPCC, 2002, 2008
3. Climate Process and Change :E Bryant, Cambridge Univ. Press, 1st edn., 1997.
4. Global Environmental Change– Past, Present and future : K K Turekian, Prentice Hall, 1st edn., 1996.
5. Global Warming – The Complete Briefing :J Houghton, Cambridge Univ. Press, 1st edn., 1997.
6. Assessing the impact of Climate Change on Natural Resource System: Frederick & Rosenberg, Kulwer Academic, 1st edn., 1994.

National Institute of Science, Technology and Development Studies (NISTADS)

Course Title: Science, Technology and Innovation Studies (STIS)

NISTADS, the one and only social sciences research lab under the CSIR (Government of India) is an academic pioneer and a policy beacon. It embodies the nation's commitment to understanding and steering the complex relationships between science and society.

The purpose of this STIS course offered by NISTADS, is to create a critical mass of scholars and practitioners with analytical competencies to lead and transform India's science, technology and innovation trajectories in economically productive, socially progressive and environmentally sustainable ways. In its academic and policy endeavours, CSIR-NISTADS operates at the interface between science and society. Through this STIS course, the research and policy expertise and experience in NISTADS will be shared with and built into a wide range of natural, physical and social science graduates. Their theoretical as well as empirical skills will ensure that they become future managers in cutting-edge S&T based industry, knowledge entrepreneurs and bureaucrats in development sectors ranging from agriculture to energy to space science, and policy analysts and advisors in national and international spheres. The state, the market and several other social, political and cultural agencies influence and shape both science and society –analysing these interactions and causal relationships demands inter-and trans-disciplinary competence. How can we enable innovation for inclusive and harmonious economic growth?

How do we prioritise our scientific research effort? What are the most effective technology commercialisation strategies available, and what are the criteria to choose the best in given contexts? How do we measure and assess scientific performance? With India's political, scientific and industrial leadership demanding these skills, this course will assemble and anneal a new inter-disciplinary and visionary generation capable of and committed to knowledge based sustainable development. This demand inspires the proposed theme of "Science, Technology, and Innovation Studies" (STIS) for the NISTADS program for Ph.D. The course curricula appropriate for STIS are currently under preparation. Broad outline of the provisional seven core courses are already drafted. Outline of twenty five optional courses have been proposed provisionally of which four courses are also drafted as samples. Details of each course would be further prepared. Since compulsory courses will require one year time (two semesters) to complete, by that time other optional courses would be developed.

NISTADS proposes to take students from all disciplines of social sciences who have an M.Phil or equivalent or who otherwise have qualified for the U.G.C. or equivalent including CAT, and also students from natural sciences and engineering and medicine who have qualified similar tests such as of the CSIR or GATE, and who are desirous of cross-disciplinary instruction.

NISTADS is also willing to collaborate with other CSIR laboratories.

Brief and provisional outline of Course Contents & Structure

On the basis of the feedback from the scientists the following courses provisionally being proposed:

a. Core courses

1. Quantitative Research Methodology – focuses on introductory statistical/econometric tools that are usually used for analysis of research question
2. Introduction to Qualitative Research
3. Indian Economy & Policy (focuses on the transition of Indian economy and her major policies since independence)
4. Innovation systems and development
5. Introduction to History of Science
6. Science & Technology Policy (focuses on policy aspects relating science and technology in India and other emerging economies)
7. Science and Technology Systems - India and the World

b. Optional courses

1. Trade & Technology (focus on the interplay between international trade, policy, FDI and technology diffusion)
2. Enterprise Development through Value Chains Analysis (EDVCA)
3. Intellectual Property Rights in the Context of Research, Innovation and Development
4. Environmental History
5. Resource Planning & Policy (RPP)
6. Institutional Economics (focuses on the role of institutions in economic
7. functioning/behaviour)
8. Advanced Econometrics
9. Law & Economics
10. Public Policy (focuses on contours of public policy formation in general and India in particular together with evaluation of their welfare implication and implementation issues)
11. Economic and Systems Modelling for Policy Analysis (focuses on different approaches to economic modelling and their use in policy analysis)
12. Organisation & Innovation (focuses on various organisational forms and their linkages with innovation)
13. Game Theory & Social Application (focuses on basics of game theory and their application in different social problems)
14. Indian Business History
15. Technology Valuation and Financing (focuses on methods of technology evaluation and financing principles)
16. Risk, Technology and Policy (focuses on capacity building for (a) analysing the relationship between the three (risk, technology and policy), and (b) using different methods for risk assessment (ex-ante and ex-post) for different contexts (social, environmental, economic, etc.) and scenarios).
17. Science, Technology and Innovation for Rural Transformation (focuses on theoretical debates about knowledge and development, and building analytical capabilities for S&T policy and innovation for rural development

18. Science, Technology and Innovation for Industries
19. Science, Technology and Innovation for Services
20. Technology, Labour and Employment (focuses on technology development, skills, labour productivity and employment)
21. Sociology of Science
22. Macro Economic Policy (focuses on in-depth study of macroeconomics)
23. Soft Computing
24. Science, Philosophy and Ethics
25. Industrial Organisation and Technology Regulation (focuses on key concepts and models of industrial organisation and how regulations relating to technology impinge on the system)
26. Science, innovation and politics

Core Course - 1
Course Title: Quantitative Research Methodology
Coordinators: Yogesh Suman, Neelam Kumar
Lecture-Tutorial- Practical-Credit: 2-1-2- 4
Total Teaching Hour: (8 Hr. Lecture, and 4.5 Hrs. Practical + Tutorial)

Objective:
The purpose is to make students capable in identifying research questions and formulating hypotheses clearly and accurately; in context of a research issue. This would help them in identifying proper data collection and analysis techniques. This will be followed by providing them thorough understanding of standard quantitative techniques.

Topics & Subtopics:
1. Introduction (1.30 Hrs.)
    - Quantitative data principals
    - Types of data-Binary, nominal, interval, ratio, ordinal
    - Inferential statistics
    - Descriptive statistics
    - Population and parameter
2. Sampling (1.30 Hrs.+ 1.30 Practical/Tutorial)
    - Sample and Statistics
    - Importance of sampling
    - Sample Size Determination
3. Sampling Techniques
 Non probability Sampling Techniques
    - Convenience Sampling
    - Judgmental Sampling
    - Quota Sampling
    - Snowball Sampling
 Probability Sampling Techniques
    - Simple Random Sampling
    - Systematic Sampling
    - Stratified Sampling
    - Cluster Sampling
4. Hypotheses Formulation and Testing (1 hr.+1.30 hr Practical/Tutorial)
    - Definition of Hypotheses
    - Null and Alternative Hypotheses
    - Critical Z values and Rejection regions
    - Z-Table for Normal distribution
    - Two Tailed Test
    - Right Tailed Test
    - Left Tailed Test
5. ANOVA (1 hr.)
    - Principal behind ANOVA

- Sum of Squares
- Mean Sum of Squares
- ANOVA Table

6. Regression (1 hr.)
   - Simple Regression And Correlation
   - Simply linear regression Model
   - Multiple regression
7. Chi Square Test (1 hr.)
8. Factor Analysis (1 hr. + 1.30 hr. practical/tutorial)

Suggested Readings

1. Allen L. Webster *Applied statistics for Business and Economics: An Essentials version* (Third Edition), McGraw-Hill.
2. Kothari, C. R. *Quantitative Techniques*, Vikas Publishing House.
3. Gupta, R. P. *Quantitative Techniques,* Daya Publishing House.

Core Course – 2
Course Title: Introduction to Qualitative Research
Coordinators: Yogesh Suman
Lecture-Tutorial- Practical-Credit: 2-1-2-4
Total Teaching Hour: 15.5 Hrs. (10 Hr. Theory, 5.5 Hr. Practical + Tutorial)

Objective:
The objective of the course is to provide students deep insight of research methodology in context of social science research. Practical illustrations from the projects done by the faculty will also be given by explaining background reasons for adopting a particular technique.

Topics & Subtopics:
1. Introduction (1.30 Hrs.)
    - Types of research
    - Pure research
    - Applied research
    - Policy research
    - Action research
    - Model for research (Examples of each type of research)
    - Characteristic of Qualitative Research
    - When to use qualitative research
    - Designing a qualitative study
2. Approaches to Qualitative research (1.30 Hrs. + 3 Hr. Practical/Tutorial)
 Narrative research
    - Types of narrative research
    - Procedures for conducting narrative research
 Phenomenological research
    - Types of phenomenology
    - Procedures for conducting phenomenological research
 Grounded theory research,
    - Types of grounded theory studies
    - Procedure for conducting grounded theory research
 Challenges, ethnographic research
    - Types of ethnographies
    - Procedure for conducting ethnographic study
 Case study research
    - Procedure for conducting a case study
 Choosing an approach to qualitative research.
 Qualitative data principals
3. Conducting interview (1.30 Hr. + 1 Hr. Practical/Tutorial)
    - Unstructured Interviews
    - Semi structured interview
    - Structured interview
4. Sociometry(1 Hr.)

5. Validity (1 Hr.)
    - Types of Validity,
    - Internal validity,
    - Construct validity
    - External validity
    - Statistical validity
    - Threats to validity
6. Non Experimental research (2 Hrs. + 1.30 Hr Practical/Tutorial)
 Observational
 Naturalistic observation
 Survey research
    - Designing a questionnaire
    - types of questions
    - Methods of administering questionnaire
    - Problems of response rate
    - Data analysis
7. Experimental research (1 Hr.)
    - Attributes and variables
    - Cause and effect
    - Control
    - Types of experimental design
8. Quasi experimental (30 Min.)
9. Ex post facto research.(30 Min)

Suggested Readings

1. Creswell, John W. *Qualitative Inquiry and Research Design Choosing among Five Approaches*, Sage Publications.
2. Guthrie, Gerard. *Basic Research Methods*, Sage Publications.
4. McBurney, Donald H and Thomson-Wadsworth. *Research Methods.*
5. Kothari, C.R. *Research Methodology - Methods and Techniques,* New Age International (P) Limited Publishers, Ansari Road Darya Ganj, New Delhi-110002.
6. Fetterman, David M. Ethnography: Step-by-Step (Applied Social Research Methods), Sage Publications.
7. Gibbs, Graham. *Analysing* Qualitative Data (Qualitative Research Kit), Sage Publications.

Core Course - 3
Course Title: Indian Economy and Policy
Coordinators: Dr Pradip Kumar Biswas & Dr Sanjib Pohit
Lecture-Tutorial- Practical-Credit: 2–1–0–3
Total Teaching Hour: 50

Objective:
The course intends to provide the students an overview of the Indian economy, its development and evolutionary process since independence.

Topics & Subtopics:
1. State of Indian economy at the time of independence with a brief discussion on colonial era
2. Planning Era
    - Need for planning
    - Planning Strategies under different plans
3. Agricultural Polices
    - Policy frames in the 1950s and the early 1960s
    - Policy shifts in late 1960s – green evolution strategies
    - Policy changes in the 1980s – diffusion of green revolution across crops, regions
    - Land holding structure, tenancy and technology change
    - Credit and insurance
    - Research and development
    - Current issues of importance
4. Industrial Policies
    - Policy frames in the 1950s to 1970s
    - Structural retrogression of Indian Industries in mid 1960s
    - Policies for SMEs and large industries
    - Economic liberation and end of license raj
    - Indian industries in the globalized world
5. Structure and Growth of the Service Sector
6. Policy support for technology diffusion and innovation
7. The External Sector
    - Indian Trade Policy and Development
    - India's Balanced of Payments – Emerging issues
    - Openness and FDI flows

Suggested Readings

1. Roy, Tirthankar, *The Economic History of India 1857-1947* (2nd edition, 2008). Chapter 3 pp.73-89; pp.97-102.
1. Chakravarty S. (1987) *Development Planning: The Indian Experience,* Clarendon Press,
2. Oxford.
3. Government of India, Planning Commission, Second Five Year Plan, and various other five-year plan documents.

4. Mohan, Rakesh (2003). “SSI Policy in India: A Critical Evaluation,” in A.O. Krueger (ed.), Economic Policy Reforms and the Indian Economy, Univ. of Chicago Press.
2. Nagaraj R. (2003). “Industrial Policy and Performance since 1980”, Economic and
5. Political Weekly, Aug.30-Sep.7
6. Goldar, Bishwanath (2004). “Indian Manufacturing: Productivity Trends in Pre- and Post-Reform Periods,” Nov. 20, Economic and Political Weekly.
3. Manoj Pant and Manoranjan Pattanayak (2005). “Does Openness Promote Competition?
7. A Case Study of Indian Manufacturing,” Economic and Political Weekly, Sept. 24.
8. Aditya Bhattacharjea (2006), Labour Market Regulation and Industrial Performance in India, A Critical Review of the Empirical Evidence, CDE, Working Paper No.141

Core Course - 4
Course title: Innovation systems and development
Coordinator: Dr. Rajeswari S. Raina
Lecture –Tutorial-Practical-Credit: 2-1-0-3
Total teaching hours: 50

Objective:
This course is to help students develop their analytical skills in understanding and enabling innovation to meet development goals. It is designed with the core courses, tutorials and one practical exercise (a case analysis or project) that can be selected by the students depending on their disciplinary orientation, context or work experience.

The use of innovation systems framework for planning and its operationalization for development demands theoretical insights and analytical competencies. This course will give students a clear understanding about the difference between (a) innovation systems, (b) technology and society, and (c) social construction/mode of knowledge production. That the components and systems relationships – interactive learning, the academic (disciplinary) contexts and policy contents, and processes involved in the analysis of each of these are different, will be made explicit. Despite increasing currency of the term innovation (as seen in India in the past three years or so), many continue to use the term as synonymous and the epistemic equivalent of technology or technology generation and diffusion. Through the lectures and tutorials in this course, the students get to use the innovation systems theoretical framework and the analytical instruments offered by several disciplines – economics, sociology, anthropology and political science in particular, to understand and enable innovation that can lead to development outcomes. The normative positions being more explicit in the innovation systems framework, helps the students see and question the assumptions made in mainstream economics and technological or technology commercialization studies therein. Covering a range of economic – Marshallian neo-classical and Marxist historical materialism, Schumpeterian evolutionary, Veblenian/Kapp institutional and evolutionary, and sociological – Feenbergian critical theory, Latourian social construction vs. Bijker-Winner social determinism, theories and analytical tools, the course sets a terrain in which the student can use the analytical narrative of the innovation systems framework to achieve development goals.

In the main semester, besides 50 hours of lecture, the course will have two tutorials. Each lecture (3 hours each) will also include discussion of the reading material. The students will be taught the basic skills of building an annotated bibliography, the design of a conceptual framework, etc.

Topics and sub-topics
1. Introducing Innovation Systems – basic definitions, framework (1 Lecture)
2. Distinguishing features – Components and processes in Innovation systems (1 Lecture)
3. Differences between innovation systems framework and technology and society (1 Lecture)

Major questions asked – debate on the use in planning (interventions or investments) for development (1 Lecture)

- Tutorial – students read and review in class three major books in Innovation Systems literature

4. Development economics – Innovation systems theory – as two estates (1 Lecture)
5. From technology black-box to economics of S&T to priority setting to science policy prescriptions – an evolutionary account of knowledge and economic growth (1 Lecture)
6. Evolutionary/Institutional economics – theoretical foundation of innovation systems (1 Lecture)
7. Macro-economics of technological change – Processes of technological and institutional innovation; structural and functional changes in components of the innovation system (1 Lecture)
8. Tutorial – students explore 3 cases of developed vs. developing countries- discuss specific macro-economic and technological change processes, identify institutional and policy changes in the cases
9. State and markets – Innovation trajectories and options from history (1 Lecture)
10. Investing in and planning for S&T – industrial, agricultural and service sector innovation systems (1 Lecture)
11. India's development experience through an innovation systems lens: a vicious circle of poverty and impeded innovation (1 Lecture)
12. Institutional setting – laying the ground rules - Mahalanobis-Nehru, Pitroda-Gandhi, and the Dhawans, Sivaramans, Pothens and Kalams (1 Lecture)
13. Socio-technological paradigms and paradigm shifters. Climate change vs. the MDGs (1 Lecture)
14. Re-cap + India's policies and investments in technology generation and extension – for major development sectors (1 Lecture)
15. Current development crisis – the digital divide, risk perceptions and occurrence, GM
16. crops, low cost vaccines/health care, small firms vs. Multinationals (1 Lecture)
17. Eco-friendly and gender sensitive innovation systems for sustainable development; India's future (1 Lecture)

Suggested Reading

1. Veblen, T. *The place of science in modern civilization*
2. Jacques, E. 1980. "Introduction: Technology and Society" in The Technological System, Continuum: New York
3. Bijker, W. E., Hughes, T. P. And Pinch, T. J. (ed.) 1989. *The social construction of*
4. *Technological Systems: New directions in the sociology and history of technology*, MIT Press: Cambridge.
5. Lundvall, B-A, 1992 (ed) *National Systems of innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter: London Kjell, Rubenson and Shuetze , H. (Ed.s) *Transition to the Knowledge Society*.
6. Nelson, R. R. 1993. *National Innovation Systems: A Comparative Study*, OUP: Oxford.
7. Edquist, C. 1997. *Systems of Innovation – Technologies, Institutions and Orgnizations*, Pinter: London.

8. Freeman, C. 1987. *Technology and economic performance: lessons from Japan*, Pinter: London.
9. North, D. C. 1990. *Institutions Institutional Change and Econ Performance*, Cambridge Unv Press: Cambridge.
10. Von Hippel, E. 1995. *The sources of Innovation*, OUP: New York.
11. Schumpeter, J. 1975. *Capitalism, Socialism an Democracy*, Harper: new York.
12. Raina, D. And Habib, I. 2008. *Domesticating Modern science*, Tulika, New Delhi
13. Feenberg, A. 1999. *Questioning Technology,* Routledge, London.
14. Feenberg, A. 1991. *Critical theory of technology*, Oxford Univ Press: New York, London.
15. Jasanoff, Sheila et al. (eds.) 1995. *Handbook of Science and Technology Studies*, Sage: London
16. Latour, Bruno 1991. "Technology is Society Made Durable", in John Law (ed). A Sociology of Monsters, Routledge, London, pp. 103-31
17. Wajcman, J. 2004. *Technofeminism, Polity Press*: Cambridge, Oxford.
18. Longino, H. 2002. *The Fate of Knowledge: Princeton*: Princeton University Press.

Core Course - 5
Course Title: Introduction to History of Science
Coordinator: Dr. Satpal Sangwan
Lecture-Tutorial-Practical-Credit: 1-2-0-3
Objectives
The course in history of science provides interdisciplinary training to research students, policy planners and science administrators for a research career or in the executive wing of state administration. It will introduce students to the principles and methods of interdisciplinary research for understanding the evolution of science as a knowledge system and state apparatus from the ancient times. It will help students to understand and appreciate the social stimulus/constraints on science, social functions of science, and the impact of science on society and economy.

Topics and sub-topics
The course in history of science will consist of the following thematic topics:

1. Science & Technology in the Ancient World
2. Science & Technology in Pre-Colonial India
3. Rise of Modern Science & Western Colonial Expansion
4. Colonial Science: Methods and Processes
5. Scientific Institutions and Scientific Community
6. Science Education and Research

The course will be a mixture of lectures, followed by guided reading, discussion and debate in the seminar sessions. In the first year of the course, students will be taught the basic theoretical and thematic subject issues. The method of delivery will be term papers, group discussion, seminar presentation and dissertation.

Suggested Readings

1. Adas, Michael. *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*, Ithaca, 1989.
2. Basalla, George. `The Spread of Western Science', *Science*, 156, May 1967, pp. 611-622.
3. Bose, D.M., S.N. Sen and B.V. Subbarayappa, eds. *A Concise History of Science in India*, Delhi: INSA, 1971.
4. Chakrabarti, Pratik, *Western Science in Modern India: Metropolitan Methods, Colonial Practices,* Delhi: Permanent Black, 2004.
5. Cohn, Bernard. *Colonialism and its Forms of Knowledge: The British in India*, Princeton: Princeton University Press, 1996.
6. Ferguson, Niall. *Civilization: The West and the Rest*, London: Allen Lane, 2011.
7. Harrison, Mark. *Climates and Constitutions: Health, Race, Environment and British Imperialism in India 1600-1850*, Oxford: Oxford University Press, 1999.
8. Headrick, D.R. *The Tentacles of Progress: Technology Transfer in the Age of Imperialism*, *1850-1940,* Oxford, 1988.
9. Hull, David L. *Science as a Process: An Evolutionary Account of the Social and Conceptual Development of Science*, Chicago: University of Chicago Press, 1988.

10. Kuhn, T.S. *The Structure of Scientific Revolutions*, Chicago: Uni. of Chicago Press, 1970.
11. Kumar, Deepak. *Science and the Raj, 1857-1905*, Delhi: OUP, 1994.
12. Lourdusamy, J. *Science and National Consciousness in Bengal, 1870-1930*, Delhi: Orient Longman, 2004.
13. Russell, Colon. *Science and Social Change 1700-1900,* London, 1983.
14. Sardar, Ziauddin. *Explorations in Islamic Science,* London: Mansell, 1989.

Core Course - 6
Course Title: Science & Technology Policy
Coordinator: Sujit Bhattacharya
Lecture-Tutorial- Practical-Credit: 2-1-0-3
Total Teaching Hour: 50
Objective:
The course intends to reach out to students with diverse background with the intention of exposing them to the issues that drive formulation of science and technology policy. It exposes students to the various socio-political-economic dimensions of S&T, complex inter-relationships between 'science and technology', 'science and society/economy', S&T and technological innovation and entrepreneurship' and evolution/dynamics of these relationships. To what extent these relationships have been affected by endogenous and exogenous actions such as the change in the institution of the scientific enterprise, new demands by the government/industry and the lay public, government and business enterprises involvement in defining the science and technology agenda, competition policy, intellectual property rights, environmental concerns, access and affordability of medicines, poverty, sustainable development will be examined through debates and discourse. The course will expose the students to the international perspective but its main focus will be in the context of India and the developing countries.
Topics &Subtopics:
1. Introduction
    - Knowledge, Invention, Innovation and Entrepreneurship- conceptual issues
    - Science its Theories and Methods
    - Facets of knowledge creation and transmission
    - The evolving relationship between Science & Technology
    - Big Science and Large Technological Systems- their dynamics and institutional arrangements
    - Science and Society- Engagements
    - Technological innovation and entrepreneurship
2. The Past and the Present of Science Policy
    - The origin of Science Policy: Emergence, historical trend and rationality
    - Science policy and the Neo Schumpeterian tradition
    - New Science Policy Agenda- Intellectual origin and challenges
    - Integrating Innovation and Entrepreneurship in S&T policy framework
    - Integrating inclusiveness and sustainable development in S&T policy framework
    - Science policy and S&T Governance
3. Science and Technology Policy in India
    - Historical evolution of S&T policy
    - Evolution of Science Policy bodies in India
    - S&T in parliament, State S&T councils
    - Funding, Human resource
    - Competition Policy, regulatory structure, IPR, Trade, etc and its role in science & technology policy formulation
    - Country strategy and policy formulation
    - Addressing Innovation and Sustainable development

- Concerns and mismatches- policy framework and socio-economic deliverance

Suggested Readings

1. Bandelj, N. (2011). The *cultural wealth of nations. Stanford*, California: Stanford University Press.
2. Bernal, J. D. (1962). Science for a developing world. London: World Federation of Scientific Workers.
3. Chesbrough, H. W. (2006). *Open innovation: researching a new paradigm*. Oxford: Oxford University Press.
4. Collins, H. M., & Pinch, T. J. (1998). *The golem: what you should know about science* (2nd ed.). Cambridge : Cambridge University Press.
5. Fagerberg, J. (2005). *The Oxford handbook of innovation*. Oxford: Oxford University Press.
6. Jasanoff, S. (1995). *Handbook of science and technology studies*. Thousand Oaks, Calif.: Sage Publications.
7. Jasanoff, S. (1997). *Comparative science and technology policy.* Cheltenham. Elgar Pub..
8. Kenney, M. (2000). *Understanding Silicon Valley: the anatomy of an entrepreneurial region.* Stanford, Calif.: Stanford University Press.
9. MacKenzie, D. A., & Wajcman, J. (1999). *The social shaping of technology. Buckingham:* Open University Press.
10. MacLeod, C. (1988). Inventing the Industrial Revolution: the English patent system, 1660-1800. Cambridge: Cambridge University Press.
11. May, C., & Sell, S. K. (2006). Intellectual property rights: a critical history. Boulder, Colo.: Lynne Rienner Publishers.
12. Nowotny, H. (2005). The public nature of science under assault politics, markets, science and the law. Berlin: Springer.
13. Price, D. J. (1963). Little science, big science. New York: Columbia University Press.
14. Porter, M. E. (1998). Competitive advantage: creating and sustaining superior performance : with a new introduction. London: Macmillan.
15. Rosenberg, N. (1982). Inside the black box: technology and economics. Cambridge: Cambridge University Press.
16. Schroeder, R. (2007). Rethinking science, technology, and social change. Stanford, Calif.: Stanford University Press.
17. Schumpeter, J. A. (2011). The entrepreneur: classic texts by Joseph A. Schumpeter. Stanford, California: Stanford University Press.
18. Snow, C. P. (1993). The two cultures (Canto ed.). London: Cambridge University Press.
19. Stokes, D. E. (1997). Pasteur's quadrant: basic science and technological Innovation. Washington, D.C.: Brookings Institution Press.
20. Visvanathan, S. (1997). A carnival for science: essays on science, technology, and development. Delhi: Oxford University Press.
21. Wagner, C. S. (2008). The new invisible college: science for development, Washington, D.C.: Brookings Institution Press.
22. Walz, R., et, al. (2008). Research and technology competence for a sustainable development in the BRICS countries. Stuttgart: Fraunhofer-IRB-Verl.

Core Course - 7

Course Title: Science and Technology Systems - India and the World
Coordinators : Dr.Tabassum Jamal & Dr. Subhan Khan
Lectures-Tutorial-Practical-Credit: 1-2-0-3
Total Teaching hours: 40

Objective:

The course in "Science and Technology Systems in India visa-vis world" provides interdisciplinary training to research students, policy planners and science administrators for a research career . It will introduce students to the dynamics and understanding for evolution of S&T systems for economic development and poverty alleviation in India and across the world.

The course will help students to look into historical glimpses on advancements of scientific and technological knowledge which made possible the significant reduction of poverty and improvements in the quality of life in both developed and developing countries throughout the 20th century which further helps the students to understand the close link between economic growth and the strategic approaches of S&T system/policies. The course will focus on the S&T system of India which besides the core S&T milieu embraces large number of economic sectors as well as social dimensions.

The course will provide the scope to study and analyze the following: *(1)* social and economic development through progress and applications of S&T; *(2)* management of S&T infrastructure (*3*) governance of S&T system (4) modes of funding

Topics and Subtopics

1. Science and Technology Policies- Comparative Study/analysis
2. India's Science and Technology Policy and its influence on technology development (Historical perspective of India's Science and Technology Policy)
3. S&T infrastructure and management of development and allocations of Developmental Plan funds to involve S&T and hence management of S&T spills over to sectors/ministries for whom S&T is not the core function
4. Evolution of sectoral policies (e.g. Human resource, health, environment, emerging technologies etc)

Suggested Readings

1. Science and Innovation Rethinking the Rationales for Funding and Governance, Edited by Aldo Geuna, Ammon J. Salter and W.Edward Steinmueller
2. Science Vol 237 No 4819, 1987 "Science and Technology policies: A comparative analyses" Leonard L. Lederman
3. Government, Innovation and Technology Policy by Sunil Mani
4. Scientific Policy Resolution, Technology Policy Statement (1983) and Science and Technology Policy (2003).
5. The strategic management of Innovation: A sociological and Economic Theory by JonSundho

Elective Course - 1
Course Title: Trade and Technology
Coordinators: Dr. Sanjib Pohit and Dr Pradip Kumar biswas
Lecture-Tutorial- Practical-Credit: 1-1-0-2
Total Teaching Hour*:* 30

Objective:
This course plans to make students aware of the theories and polices that has led to the globalization of the world economy. The course has three main components namely, international trade, foreign direct investment and international technology transfer. The emphasis on each component is to analyze the channels that are the driving force behind globalization of an economy

Topics & Subtopics:
1. International Trade
   - The underlying causes of foreign trade
   - Brief review of trade theories and trade policies
   - Trade restriction and its instruments
   - The roles of trade in fostering economic development
   - Foreign trade and trade policies in India
   - Rationale of the changes in policies since independence
   - Key emerging issues
2. Foreign Direct investment
   - Why do firms internationalize
   - Reasons for international factor movement
   - Brief review theories of FDI
   - Potential benefits and costs of FDI for a host country
   - The roles of FDI in economic development
   - FDI inflows in India and the policy frame
   - Characteristics of FDI in flows in India
3. International technology transfer
   - Types of technology and knowledge transfer
   - General channels for technology transfer and their influences on production
   - Brief review approaches of international technology transfer
   - International operation of national firms (transferability of comparative and competitive advantage)
   - Conditions of host and home countries for technology transfer
   - Theoretical implication of international technology transfer
   - Technology transfer in India
   - Technology spillover & Intellectual property right protection in India
   - Technology development in India

Suggested Readings
1. Appleyard, D.R., Field, J.R., Alfred, J., & Cobb, S.L., 2008. *International Economics*.. McGraw-Hill.

2. Dunning, John H. & Lundan, S.M., 2008. *Multinational Enterprises and the Global Economy.* Cheltenham, Northampton: Edward Elgar.
3. United Nations 2008. *World Investment Report: Transnational Corporations and infrastructure challenge 2008.* United Nation.
4. Krugman, P. and Obstfeld. 2009. *International Economics: Theory and Policy*, Pearson.

Useful Websites:

1. WTO, http://www.wto.org
2. UNCTAD, http://www.unctad.org
3. The World Bank, http://www.worldbank.org
4. Alan Deardorff's Glossary of International Economics Terms, http://wwwpersonal.umich.edu/~alandear/glossary

Elective Course - 2
Course Title: Enterprise Development through Value Chains Analysis
Coordinators: Dr M. Rais
Lecture-Tutorial- Practical-Credit: 2-0-2-3
Total Teaching Hour: 64 (lecture - 32 hours, lab - 32 hours)

Objective:
To train development professionals in order to increase the impact, scale and sustainability of initiatives that help small enterprises (SEs) grow, create jobs and reduce poverty. Value Chain Analysis enables us to understand competitive challenges and to identify vertical coordination mechanisms. Value Chain Development aims to improve access to markets and increase productive efficiency, ensuring that all actors including the resource-poor, benefit from these value chains.

Topics & Subtopics:
1. Value Chains: Introduction
    - Introducing the value chain approach
    - Identify and scan sub sectors
    - Develop and apply selection criteria
    - Developing maps to visualise the analyses
    - Determine and measure dimensions of interest
2. Analysis of value Chains
    - Undertaking economic analyses of value chains
    - Define critical success factors for value chains and actors
    - Upgrade strategic options and combinations
    - Development models and accompanying roles of stakeholders
    - Guest speaker: practices from the field
3. Application of Value Chains
    - Facilitate value chain development process
    - Financial instruments the financial institutions
    - Applying tools in your real life case
    - Applying tools in real life case
    - Presenting and discussing the results of the real life case
    - Planning next step in developing value chains
4. Value Chain Examples from Field
    - Analysis of own value chain – which costs are related to every single activity
    - Analysis of customers value chains – how does our product fit into their value chain
    - Identification of potential cost advantages in comparison with competitors
    - Identification of potential value added for the customer – how can our product add value to the customers value chain (e.g. lower costs or higher performance) – where does the customer see such potential

Suggested Readings
1. Kaplinsky, Raphael and Morris, Mike (2000) *A handbook for value chain research* (IDRC).

2. Schmitz, Hubert (2006). Value chain analysis for policy makers and practitioners.
3. Michael E. (1985) *Competitive Advantage: Creating and sustaining superior Performance.*

Elective Course - 3
Course Title: Intellectual Property Rights in the Context of Research, Innovation and Development
Coordinator: Sujit Bhattacharya
Lecture-Tutorial- Practical-Credit: 2-1-0-3
Total Teaching Hour: 50

Objective:
The students would be able to learn the nuances of various forms of Intellectual property and their effectiveness in protecting various forms of creativity. They will be exposed to intellectual property innovation and development nexus and conflicts of interest that emerge and how IPR management can be undertaken effectively.

Topics and Subtopics:
1. Knowledge, Innovation and Intellectual Property Rights: An Introduction
2. Evolution of IP Statutes – Origin and Internationalisation
3. Contemporary IP Statues: Unification of IP rights
4. IPR and New Technologies
5. IPR in India
6. Debates on IPR and Development

Suggested Readings

1. Smith, G and Parr, R.L (1989) Valuation of Intangible Assets. New York: John Wiley & Sons Inc.
2. Cottier, Thomas and Mavroidis, C. Petros (2003). Intellectual Property: Trade, Competition, and Sustainable Development. World Trade Forum, Volume 3. The University of Michigan Press.
3. Berman, Bruce and Woods, D. James (2002). From Ideas to Assets- Investing Wisely in Intellectual Property. Willy Intellectual Property Series. New York: John Wiley & Sons Inc.
4. Background Discussion Papers and Occasional Papers by Quaker United Nations Office Geneva.
5. Commission on Intellectaul Property Rights, Innovation and Public Health (CIPH): Publications and Study Materails (http://www.who.int/intellectualproperty/en/)
6. Intellectual Propert Management in Health and Agricultural Innovation- a handbook of best practices. (www.ipHandbook.org)

Elective Course - 4
Title: Environmental History
Coordinator: Dr. Satpal Sangwan
Lecture-Tutorial-Practical-Credit: 1-2-0-3

Objectives
The course will introduce students to the principles and methods of interdisciplinary research for understanding the ever-evolving convergence of science, society and environment. The course will help students to understand and analyze changing human use/abuse of natural resources on the one hand and also to examine the human understanding and appreciation of the dynamics of natural systems. The main focus will be on the role of culture, ethics, social demands, economy and technology on resource use patterns at different intervals of human history.

Topics and Sub-Topics
1. Society and Environment in the Ancient World
2. Collapse of Civilizations: Environmental Causes
3. Colonialism, Capitalism and Environment
4. Global Warming: Myth or Reality
5. Environmental Movements
6. International Environmental Negotiations/Agreements.

The course will be a mixture of lectures, followed by guided reading, discussion and debate in the seminar sessions. In the first year of the course, students will be taught the basic theoretical and thematic subject issues. The method of delivery will be term papers, group discussion, seminar presentation and dissertation.

Suggested Readings

1. Arnold, David and R. Guha eds., *Nature, Culture and Imperialism: Essays on the Environmental History of South Asia,* Delhi: Oxford University Press, 1994.
2. Chew, Sing C., *World Ecological Degradation: Accumulation, Urbanisation, and Deforestation 3000 B.C-A.D. 2000*, California Altamira: Walnut Creek, 2001.
3. Crosby, Alfred W., Jr., *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*, Cambridge: Cambridge University Press, 1986.
4. Diamond, Jared, *Collapse: How Societies Choose to Fail or Survive*, Penguin Books, 2011
5. Fagan, Brian, *The Long Summer: How Climate Changed Civilization*, London: Granta Books, 2004.
6. Fleming, Thomas Rodger, *Historical Perspectives on Climate Change*, NY: Oxford University Press, 1998.
7. Gadgil, Madhav and Ramchandra Guha eds., *This Fissured Land: An Ecological History of India*, Delhi: Oxford University Press, 1992.
8. Gadgil, Madhav and Ramchandra Guha, *Ecology and Equity: The Use and Abuse of Nature in Contemporary India,* London: Routledge, 1995.

9. Grove, Richard, Vinita Damodaran and Satpal Sangwan eds., *Nature and the Orient: The Environmental History of South and Southeast Asia*, eds., Delhi: Oxford University Press, 1998.
10. Hughes, J.D., *Ecology in Ancient Civilizations*, Albuquerque: University of New Mexico Press, 1975.
11. Hughes, D., *Pan's Travail: Environmental Problems of the Ancient Greeks and Roman*, Baltimore: John Hopkinns University Press, 1994.
12. Lamb, H., *Climate: Present, Past and Future,* 2 vols., London: Methuen, 1977.
13. Lawson, Nigel, *An Appeal to Reason: A Cool Look at Global Warming*, Harper Collins, 2009.
14. Ponting, C., *A Green History of the World: The Environment and the Collapse of Great Civilizations*, New York: Penguin Books, 1993.
15. Richards, J.F., *The Unending Frontiers: An Environmental History of the Early Modern World,* Berkeley: University of California Press, 2003.
16. Sen, Geeti, (ed.), *Indigenous Vision: Peoples of India's Attitudes to the Environment*, Delhi: Sage Publications, 1992.
17. Shiva, Vandana, *Ecology and the Politics of Survival: Conflicts over Natural Resources in India*, Delhi: Sage Publications, 1991.
18. Weart, S.R. *The Discovery of Global Warming: New Histories of Science, Technology and Medicine*, Massachusetts: Harvard University Press, 2003.
19. Williams, M., *Deforesting the Earth: From Pre-history to Global Crisis*, Chicago: University of Chicago Press, 2003.
20. Worster, Donald (ed.), *The Ends of the Earth: Perspectives on Modern Environmental History*, Cambridge: Cambridge University Press, 1988.

Elective Course - 5
Course Title: Resource Planning & Policy
Coordinators: Tabassum Jamal, Kasturi Mandal, Subhan Khan, M. Rais
Lecture-Tutorial- Practical-Credit: 1-1-1-2
Total Teaching Hour*:* 40

Objective:
The course will have an inquiry driven approach to examine the formulation of resource planning and policy based on theoretical exposition in the domain of macroeconomics particularly the post Keynesian school in economics by addressing the core issues such as, the strength of communities and nations is primarily determined by two aspects, viz.

- the availability of resources they have and,(ii) the capacity they have to utilize these in a rational manner.
- Those communities and nations have been less developed which could not sufficiently develop the capability to exploit their resources rationally and also those whose resources are over exploited by others.
- For developing capabilities, making use of resources and evolving institutional framework for enough utilization of their resources, importance of planning & policy making of resources become much important.

Topics and Subtopics:
1. Historical Context of Resources Evaluation
2. Regional Development
3. Resources Utilization in Marginal Areas/stressed lands
4. Resources &Environment
5. Natural & Human Resources Interaction
6. Resources & Poverty Alleviation
7. Geospatial technology applications in resources assessment and planning

Suggested Readings
Websites
1. www.ask.com/Planning+Resources
2. ibrary.columbia.edu/indiv/avery/guides/urban_planning.print.html
3. www.ifc.org/ifcext/enviro.nsf/.../p.../ResettlementHandbook.PDF
4. store.bizmanualz.com/Human-Resources-Policies-and.../abr41m.htm
5. www.w3.org/WAI/intro/accessibility.php

Books
1. Chatterji, Manas, Peter Niojkamp, T.R. Lakshmanan & C.R. Pathak. *Spatial, Environmental and Resource Policy in the Developing Countries*, published by Gower
2. Handbook for Preparing a Resettlement Action *Plan*
3. The *Policy* Process - ODI Working Papers 118 - Working paper
4. *Basic* Description of Strategic *Planning* (including key terms to know)
5. Foundations of Real-Time Computing: Scheduling and Resource Management
6. Resource Management In Real-Time Systems And Networks
7. Water Resource Policy

8. Locked Horns: Conflicts and their Resolution in Community Based Natural Resource Management
9. Mineral Resources and Policy in India
10. Forest Resource Policy
11. Human Resource Policy: Concepts, Processes And Applications
12. Renewable Resource Policy: The Legal-Institutional Foundations
13. Environmental and Resource Policy for Consumer Durables
14. Distributional Conflicts in Environmental-Resource Policy
15. Regional Perspectives *on Resource Policy*: Implementing.
16. *Policy* Instruments for Environmental and Natural *Resource*.