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