DEPARTMENT OF FUTURES STUDIES

UNIVERSITY OF KERALA

M.Phil PROGRAMME IN FUTURES STUDIES

SYLLABUS

(Under Credit and Semester System w.e.f. 2016 Admissions)

UNIVERSITY OF KERALA

DEPARTMENT OF FUTURES STUDIES

M.Phil Programme in Futures Studies

Aim: The M.Phil Programme in Futures Studies aims to make the students to conceive and constitute objects for research that belong to interdisciplinary areas with special emphasis on science, technology and its relationship with society with a futuristic outlook. It also intends to equip the students with forecasting and futuristic problem solving methods in their basic areas of specialization.

Objectives

- To introduce the students to advanced areas of research in their basic domain with a futuristic outlook.
- To make the students competent in literature collection pertaining to his/her study area.
- To make the students to do independent field work and data collection.
- To prepare the students for undertaking analysis with the help of computational tools and softwares.
- To prepare the students to undertake serious research and train the students in better scientific communication.

Structure of the Programme

Semester No.	Course Code	Name of the Course	Number of Credits
I	FUS-711	Interdisciplinary Research & Research Methodology	4
	FUS-712	Scientific Computing and Forecasting	4
	FUS-713(i)	Technological Futures, Forecasting and Assessment	4
	FUS-713(ii)	Computational Chemistry	4
	FUS-713(iii)	Molecular Modeling and Molecular Dynamics	4
	FUS-713(iv)	Optimization Techniques	4
	FUS-713(v)	Nonlinear Dynamics and Chaos	4
	FUS-713(vi)	Computational Physics	4
	FUS-713(vii)	Computational Biology and Bioinformatics	4
	FUS-713(viii)	Operations Research and Decision Theory	4
	FUS-713(ix)	Discrete Mathematics and Combinatorics	4
	FUS-713(x)	Econometrics and Economic Forecasting	4
II	FUS -721	Dissertation	**20**
		TOTAL CREDITS	**32**

Semester **: I**
Course Code **: FUS-711**
Course Title **: Interdisciplinary Research & Research Methodology**
Credits **: 4**

AIM: The main concepts and categories, along with different methodologies and methods, in the domain of Science, Applied Sciences, Engineering& Technology are introduced for erudite learning.

Objectives:

- To introduce the core issues in the philosophy of science, in particular to the central debates in the history and philosophy of science to understand the terminology and concepts presupposed by advanced literature in the area.
- The course focuses on the methods and techniques of research according to different research paradigms
- To apply their knowledge of the subject to contemporary debates about science policy, uncertainty and risk and the controversy about alternatives in futures studies and technology management.

Module I: Survey of Research Methodologies- Rationalism, Idealism, Positivism, Post Positivism, Introduction to major binaries, Subjectivity vs Objectivity, Realism vs Anti –realism, True vs False, Scientific evolution vs Scientific Revolutions, Continuity vs Discontinuity, Deterministic vs Probabilistic, Linearity vs Non –Linearity, Beyond the binaries

Module II: Methods: Epistemology, Ontology, Deduction, Induction, Hypothetical Deductive method, Explanation and Prediction, General and Particular, Cause and Effect.

Module III: History and Philosophy of science, Scientific revolutions, Paradigms, Against Method, Epistemic shift. From Methodology to Methodologies

Module IV: Techniques-Foresight and Futures Research: Quantitative Techniques , Techniques of generating data, Techniques of classification, Techniques of measures , Central Tendency and Dispersion, Measures of Correspondence/Correlation, Measures of Causal relations/Regression, Techniques of Explanation ANOVA, Time Series Analyis-ARMA,Adaptive Estimation Procedures (Kalman Filters) Techniques of inference , Introduction to Futures Research, Foresight Studies, Methods/techniques of Futures Research and Foresight Studies , Qualitative – Delphi, PRA ,RRA etc.

Module V: Advanced Techniques- Advanced Statistical Methods for data Analysis, Structural, quantitative, or statistical approaches for the analysis of data, Advances in classification, clustering and pattern recognition methods, Strategies for modeling complex and network data, Complex Network analytics, mining large data sets, Chaos analysis and its measurement, Methods for the extraction of knowledge from whatever type of data, and Application of advanced methods in specific domains of practice.

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

REFERENCES

- Abraham Kaplan, 1964, *Conduct of Inquiry*, Chander Publishing Company, California.
- Ann Majchrzak, 1984, *Methods for Policy Research*, Sage London
- Carl G Hempel*"The Covering Law Analysis of Scientific Explanation"* in Leonard I Krimerman (ed)
- Catheriner Marsh, 1988, *Exploring Data*, Polity Press, Cambridge
- Cohen and Ernest Nagel (ed) 1978, An Introduction to Logic and Scientific Method, Allied, New Delhi
- Jean-Francois Lyotard, 1986, *The Post Modern Condition*: *A Report on Knowledge*, The Manchester University Press, Manchester
- John Brewer and Albewrt Hunter, *Multimethod Research*: *A synthesis of Styles*, Sage Publications, London.
- John Hughes, 1990, *The Philosophy of Social Research*, Longman, London
- Karl R Popper, "*The Hypothetical – Deductive Method and the Unity of Social and Natural Science",* in Leonard I Krimerman (ed)
- Keith Lehrer, 1990, *Theory of Knowledge*, Routledge, London
- Leonard I Krimerman (ed) *The Nature and Scope of Social Science*, Apple-Century –Croafts, New York
- Margolis J Kransz, and Burian R M, (EDS) 1986, *Rationality, Relativism and Human Sciences,*Nijhoff Publications, Dordrecht.
- ParthaNathMukherji , 1998 , *Methodology in Social Research* ,Sage , New Delhi
- Paul Feyerabend, 1984, *Against Method*, Verso, London
- Pauline V Young, 1988, *Scientific Social Survey Research*, Mcgraw-Hill Book Company, New York
- Peter Clough and Cathy Nutbrown, 2002, *A Students Guide to Methodology*, Sage Publications, London
- Thomas S Khun, 1970, *The Structure of Scientific Revolution*, University of Chicago Press, Chicago
- Olaf Helmer, Looking Forward, Sage, 1979

Semester **: I**
Course Code **: FUS-712**
Course Title **: Scientific Computing and Forecasting**
Credits **: 4**

Aim: To present a framework and analytical tools for developing systems modelling using scientific computing techniques. To introduces different tools, techniques and methods for scientific computing and modelling dynamic systems capable of making forecast.

Objectives:

- To develop an understanding of the framework and importance of Scientific Computing and forecasting in any relevant discipline.
- To gain exposure to concepts and tools used for Scientific Computing, forecasting and modelling.
- To learn how to develop a model for a dynamic system.

Module I: Introduction to systems modelling: Theoretical *vs.* computational modelling-Stages of computational modelling, Abstraction of idea – properties of models, Importance of virtual experiments in science and technology.

Module II: Numerical methods for scientific computing – Solution of Linear Algebraic Equations, Interpolation and Extrapolation , Random Number generation, Linear and Nonlinear curve fitting of Data, Solution of ODEs and PDEs, Fast Fourier Transform. Programming of these methods using Fortran and C.

Module III: Time Series Analysis & Forecasting- Identification, Estimation and Diagnostic Techniques for ARMA and ARIMA Models. Seasonal ARIMA models. Exponential smoothing and ARIMA models.

Module IV: Introduction to spectral analysis. Transfer function models. State Space models and Kalman filters. Design of Feed Forward and Feed backward Control Schemes.

Module V: Introduction to computer algebra systems - Matlab, Scilab and SAGE, Neural networks, Genetic algorithm, Cellular automata and R

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage

REFERENCES:

- Gaston H. Gonnet, Ralf Scholl, Scientific Computation, Cambridge University Press, 2009
- Eric F. Van de Velde, Concurrent scientific computing, Springer, 1994
- William H. Press, Numerical recipes: The art of scientific computing, Cambridge University Press, 2007
- Dietmar P. F. Moeller, Mathematical and computational modeling and simulation: Fundamentals and Case Studies, Springer, 2004
- Charles S. Taber, Richard J. Timpone, Computational modeling, SAGE, 1996.
- Bovas, A. and Johannes, L (1983), Statistical Methods for Forecasting, John wiley, New York.
- Box G.E.P. and Jenkins, G.M.(1976), Time Series Analysis Forecasting and Control, san Francisco.

Semester : I
Course Code : FUS-713(i)
Course Title : Technological Futures, Forecasting and Assessment
Credits : 4

Aim: To present a framework and analytical tools for developing technological foresight. It introduces technology monitoring, forecasting, and assessment in the context of one or more families of emerging technologies.

Objectives:

- To develop an understanding of the framework and importance of technology forecasting.
- To gain exposure to concepts and tools used for technology forecasting.
- To learn how to develop a technology forecasting program for a typical organization.

Module I: The rapidly changing technological scene and the need for competitiveness and economic growth/ development -Role of technology forecasting in development planning - Technology forecasting as a tool for corporate strategy - Technology forecasting as a tool for social strategy - Stage of innovation –

Module II: Methodologies of Technology forecasting and Futures Problem solving- Computer modelling techniques – Sensitivity analysis for models –

Module III: Features of technology assessment - Objectives of technology assessment - Distinction between technology assessment and environment impact analysis - Types of technology assessment / environment impact analysis –

Module IV: Technology assessment as a map for alternate futures - components of technology assessment - the technology delivery systems - social impact analysis - Limitations of technology forecasts and assessment - case studies of technology forecast and assessment.

Module V: Future technological options - environmental friendly technologies - appropriate technology - case studies of technological futures: bio technology, information technology, Nano Science and technology, Bio-Informatics, Energy technology options (source wise) – R and D in technology development

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage

REFERENCES

- Technological Forecasting for Decision Making, Joseph Martino, Tata McGraw-Hill
- Forecasting Technological Innovation. B. Henry, Kluwer
- Forecasting & Management of Technology -Alan.L.Porter, Wiley Series
- Technology in Context: Technology Assessment for Managers (Management of Technology and Innovation), Ernest Braun, Rutledge
- Perspectives on technology assessment- Sherry R. Arnstein, Alexander N. Christakis,Science and Technology Publishers

Semester : **I**
Course Code : **FUS-713(ii)**
Course Title : **Computational Chemistry**
Credits : **4**

Aim: The objective of the course is to highlight the basic principles necessary to understand the properties of atoms and molecules and their chemical reaction.

Objectives

- To gain basic knowledge in different methods for the calculation of molecular properties.
- To provide a basic understanding of computational chemistry.

Module I: Introduction to quantum mechanics, Schrodinger Equation, Quantum mechanics applied to simple problems such as particle in a 1D box, harmonic oscillator, rigid rotor, hydrogen atom solutions, multi-electron systems

Module II: Building molecules (3D structures), Stereochemistry, Molecular Symmetry

Module III: Empirical and semi-empirical molecular orbital theory : Qualitative and Qualitative MO theory, Hückel method, Semi empirical methods such as AM1, MNDO etc.

Module IV: Basic Ab initio quantum chemistry :Ab initio and semi-empirical methods, Introductory DFT, Basis set, hybrid calculations

Module V: Molecular Mechanics and Dynamics: Molecular Potential Energy Functions, Molecular Mechanics, Molecular Mechanics Force Field, Optimisation, Selecting force field, Parameters and other problems with Molecular Mechanics, Molecular Dynamics: Simulated Annealing, Monte Carlo Simulations

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- Christopher J. Cramer, Essentials of Computational Chemistry: Theories and Models, John Wiley and Sons, 2004
- Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics, Springer, 2003
- David C. Young, Computational chemistry: a practical guide for applying techniques to real world problems John Wiley and Sons, 2001
- Frank Jensen, Introduction to computational chemistry, Wiley, 1999
- Computational Chemistry: Reviews of Current Trends by Jerzy Leszczynski

Semester : I
Course Code : FUS-713 (iii)
Course Title : Molecular Modeling and Molecular Dynamics
Credits : 4

Aim: To provide a brief Introduction to Molecular Modelling with Examples of Application Areas

Objectives: To explores a wide range of techniques and applications in molecular modelling and dynamics

Module I: Computational Chemistry .concepts of computational chemistry-Born-Oppenheimer approximations, Application of Hartree-Fock equations to molecular systems, approximate molecularorbital theories, semi-emperical methods. Macro-molecular force fields, salvation , long range forces.

Module II: Molecular Mechanics: general features, bond stretching, angle bending, improper torsions, out of plane bending, cross terms, non-bonded interactions, Ramachandran diagram point charges, calculationof atomic charges, polarization, van der waals interactions, hydrogen bond interactions, Water models,Force field, all atoms force field and united atom force field.

Module III: Energy minimization: Steepest descent, conjugate gradient – Derivatives, First order steepest decent and conjugate gradients. Second order derivatives Newton-Raphson, Minima, maxima saddlepoints and convergence criteria.-non derivatives minimization methods, the simplex, sequential univariate.

Module IV: Simulation methods : Newton's equation of motion, equilibrium point, radial distribution function, pair correlation functions, MD methodology, periodic box, Solvent access, Equilibration,cutoffs, algorithm for time dependence; leapfrog algorithm, Verlet algorithm, Boltzmann velocity, timesteps, duration of the MD run, Starting structure, analysis of MD job, uses in drug designing, ligandprotein interactions. Various methods of MD, Monte Carlo, systematic and random search methods.Differences between MD and MC, Energy, Pressure, Temperature, Temperature dynamics ,simulation softwares. Various methods of MD, Monte Carlo, systematic and random search methods.

Module V: Docking and Drug design : Discovery and design of new drugs, computer representation of molecules, 3d database searching, conformation searches, derving and using the 3d Pharmacophore,- keys constrained systematic search, clique detection techniques, maximum likelihood method, moleculardocking, scoring functions, structure based de novo Ligand design, quantitiative structure activity relationship QSAR, QSPRs methodology, various descriptors quantum chemical . use of geneticalgorthims, Neural Network and Principle components analysis in QSAR equations. Combinatoriallibraries, design of "Drug like" libraries.

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage

References

- Andrew R.Leach Molecular Modelling Principles and applications . (2001) II ed . Prentice

Hall.

- Fenniri, H. “Combinatorial Chemistry – A practical approach”,(2000) Oxford University Press, UK.
- Lednicer, D. “Strategies for Organic Drug Discovery Synthesis and Design”; (1998) Wiley International Publishers.
- Gordon, E.M. and Kerwin, J.F “Combinatorial chemistry and molecular diversity in drug discovery”(1998) Wiley-Liss Publishers.

Semester : I
Course Code : FUS-713(iv)
Course Title : Optimization Techniques
Credits : 4

Aim: To understand basic mathematical theory and techniques for solving optimization problems

Objectives

- To provide advanced optimization techniques for problems arising in logistics, manufacturing, transportation, and many other fields
- To provide intense coverage of modelling and optimization problem solving.

Module I: Review-Sets and Sequences in $\boldsymbol{R}^n$ Sequences and Limits, Subsequences and Limit Points, Cauchy Sequences and Completeness, Suprema, Infima, Maxima, Minima, Monotone Sequence in $\boldsymbol{R}$, The Lim Sup and Lim Inf, Open Balls, Open Sets, Closed sets, Bounded sets and Compact Sets, Convex Combinations and Convex Sets, Unions, Intersections and other binary operations, Matrices, Functions, Quadratic forms, Separation Theorems, The intermediate and Mean value theorems, The inverse and implicit function theorems

Module II: Optimization problems in $\boldsymbol{R}^n$, Optimization problems in parametric form, Examples of optimization problems – Utility maximization, expenditure minimization, profit maximization, cost minimization, consumption-leisure choice, portfolio choice, Objectives of optimization theory -Existence of Solutions , The Weierstrass Theorem, Unconstrained Optima

Module III: Equality Constraints and the Theorem of Lagrange, Second order conditions, Inequality Constraints and the Theorem of Kuhn and Tucker, Convex Structures in Optimization Theory, Concave and Convex functions, Implications of convexity, Convexity and optimization,

Module IV: Quasi – Convexity and Optimization,Quasi-convexity as generalization of convexity, Parametric continuity: The maximum theorem, The maximum theorem under convexity, Finite - Horizon Dynamic Programming, Stationary Discounted Dynamic Programming.

Module V: Numerical Optimization Techniques- Unconstrained multi-parameter optimisation techniques, Nelder-Mead's sequential simplex method, Powell's conjugate directions method, Fletcher-Reeves' Conjugate Gradient method, Newton's Method, Quasi-Newton Method.

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- R. K. Sundaram, A First Course in Optimization Theory, Cambridge Uni. Press, 1996.
- C. Mohan , Kusum Deep, Optimization Techniques, New Age Science, 2009
- T. Back, *Evolutionary Algorithms in Theory and Practice*, Oxford Uni. Press, New York, 1995
- D. E. Goldberg, *Genetic Algorithms in Search Optimization and Machine Learning*, Addison-Wesley, 1989.
- J. Nocedal, and S. J. Wright, *Numerical Optimization,* Springer, 1999.
- U. M. Diwekar, *Introduction to Applied Optimization*, Kluwer Academic Publishers, 2003

Semester : I
Course Code : FUS-713(v)
Course Title : Nonlinear Dynamics and Chaos
Credits : 4

Aim: To understand the basic theory of nonlinear dynamics and chaos with applications to forecasting and modelling of time series data.

Objective

- To provide basic knowledge on nonlinear dynamics and Chaos theory and its applications.
- To provide an intuitive approach with emphasis on geometric thinking, computational and analytical methods

Module I: Brief History of Dynamics, Review – Chaos, Fractals and Dynamics

Module II: One dimensional flows, Fixed points and stability, Bifurcations, Flows on a circle

Module III: Two dimensional flows, Linear systems, Phase Plane, Limit cycles

Module IV: Bifurcations, Chaos, One dimensional Maps – Fixed points and cobwebs, logistic map, Fractals, cantor set, different dimensions and Strange attractors

Module V: Nonlinear time series analysis using TISEAN package

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- Steven H. Stogatz, Nonlinear dynamics and chaos – with applications to Physics, Biology, Chemistry and Engineering., Perseus Books Publishing, 1994
- James Gleick, chaos – making of a new science, Penguin, 1987
- Katheleen T. Alligood, Tim D. Sauer, james A. Yorke, Chaos: an introduction to dynamical systems, Springer, 1996
- Richard Kautz, chaos: The science of predictable random motion, Oxford university press, 2011
- *HolgerKantz, Thomas Schreiber, Nonlinear Time Series Analysis, Cambridge University Press, 2004*
- TISEAN: Nonlinear Time Series Analysis - *https://www.pks.mpg.de/~tisean/*

Semester : I
Course Code : FUS-713(vi)
Course Title : Computational Physics
Credits : 4

Aim: To provide detail computational skills, needed to work in classical and quantum physics using appropriate softwares.

Objectives

- To understand basic concepts to familiarizes students with the computational tools which are essential for graduate students in computational physics and related areas.

Module I: Introduction to Computational Physics, Classical Physics and statistical mechanics, Stochastic simulations, electrodynamics and hydrodynamics

Module II: Quatom mechanics, Relations between quantum mechanics and classical statistical mechanics Quantum scattering with spherically symmetric potential, calculations of scattering cross sections

Module III: The variational method for the Schrodinger equation, variational calculus, examples of variational calculations, solution of the generalised Eigen value problem, perturbation theory and variational calculus

Module IV: Density function theory, The local density approximation, one and two particle excitations Solving the Schrodinger equation in periodic solids-Classical equilibrium statistical mechanics, Molecular dynamics simulations, Quatum molecular dynamics,

Module V: The Monte Carlo method Quantum Monte Carlo methods, The finite elements method for partial differential equations

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- J. M. Thijssen, computational Physics, second edition, Cambridge University Press, 2007
- D. K. Jha, Computational Physics, Discovery publishing House, 2009
- Rubin H. Landau, Manuél José PáezMejía, Cristian C. Bordeianu -*Computational Physics*: Problem Solving With Computers - John Wiley & Sons, 2007

Semester : **I**
Course Code : **FUS-713(vii)**
Course Title : **Computational Biology and Bioinformatics**
Credits : **4**

Aim: To provide an interdisciplinary framework of procedures and methods from computer science developed and deployed to address and solve important current problems in biology.

Objectives

- To familiarize the students with the basic computational tools and methods to solve current problems in molecular and evolutionary biology

Module I: Introduction to molecular biology, Genomics, Proteomics and Bioinformatics. DNA, Proteins, Genetic code, t-RNA and protein sequences, Metabolic Metabolic Pathways and Analyses, Information retrieval with Entrez and Web browsers.

Module II: Human Genome Project, Genome and Sequence Databases, Datamining results of genome projects, Protein Sequence and Motif Databases, Sequence Alignment, Sequence Similarity Search, Multiple Sequence Alignment, Visualization of sequence data; Visualization of structures using Rasmol or SPDB Viewer. Finding protein coding regions, Finding genes

Module III: Clustering gene expression pattern, Coordinately Regulated Genes, Discovering Gene Regulatory Signals. Gene Regulatory Modules and Networks, Prediction of macromolecular properties. Restriction Maps, Multiple Maps,

Module IV: Algorithms for DDP – Approaches to DDP- Simulated annealing, Mapping with real data, Cloning and clone libraries, Physical genome maps, Oceans, Islands and anchors-RNA secondary structure :Combinatorics, counting shapes, minimum energy structures. Trees and sequences: – splits, matrices on trees, distance, parsimony, maximum likehoold trees –

Module V: Counting time Markov Chains, estimating rate of change, likehood and trees. Hidden Markov Models.

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- Haubold, Bernhard, Wiehe, Thomas, Introduction to Computational Biology: An Evolutionary Approach, Springer, 2006
- Michael S. Waterman, Introduction to Computational Biology : Maps, Sequences and genomes, Chapmann& Hall/CRC 1995
- Introduction to Computational Biology: An Evolutionary Approach, Bernhard Haubold, Thomas Wiehe, Birkhäuser Basel, 2006.
- Richard E. Neapolitan, Probabilistic Methods for Bioinformatics: with an Introduction to Bayesian Networks, Morgan Kaufmann, 2009
- Neil C. Jones, Pavel A. Pevzner, An Introduction to Bioinformatics Algorithms, MIT Press, 2004.

Semester : I
Course Code : FUS-713(viii)
Course Title : Operations Research and Decision Theory
Credits : 4

Aim: To study how to obtain the best decisions (according to a well–defined objective) in allocating scarce resources such as capital, materials, equipment, manpower, energy, etc. among competing activities that produce goods and services.

Objectives

- To focus on a class of problems that can be modelled as a Linear Programming Model.
- To provide methodological development including simplex algorithm, theorems of duality, complimentary slackness, and sensitivity analysis.
- To provide introductory material on Game theory, Non-Linear programming, Queuing/Waiting Line Models

Module I: Introduction to OR - History, nature, scope and phases - OR and decision theory – Types of models in OR - Guidelines for modelling an OR project

Module II: Structure of decision strategies - Decision trees -Decision under competitive situation –Theory of games - pure and mixed strategies –

Module III: Linear programming – Formulation, Theory and algorithms-Primal and Dual simplex algorithms and Interior point algorithms

Module IV: Post optimality analysis - complications in LP problems and resolutions - Goal programming

Module V: Waiting line models and their industrial applications

End-Semester Assessment
This will be through a written exam of three hours duration of 100 % weightage.

References

- Billy E. Gillett, Introduction to Operations Research: A Computer-Oriented algorithmic approach, Tata McGraw-Hill, 1979
- HamdyTaha, Operations Research, PHI, 2009
- George Bernard Dantzig and MukundNarainThapa, Linear programming: theory and extensions 1& 2 , Springer, 2017
- L.A Woolsey and G .L Nemhauser ,Integer and Combinatorial Optimization — John Wiley, 1988

Semester : I
Course Code : FUS-713(ix)
Course Title : Discrete Mathematics and Combinatorics
Interdisciplinary Research & Research Methodology
Credits : 4

Aim: To provide a basic course in Discrete and Combinatorial Mathematics is needed to understand mathematical structures in the object of one's interest and understand the properties.

Objectives

- To deliver techniques and ideas in discrete mathematics and basic combinatorial techniques for counting, selecting and arranging along with classical mathematical logic and proof techniques.
- To understand the basic concepts of algorithms, their analysis and computational complexity for solving discrete optimization problems

Module I: Introduction to Combinatorics -Principles of Counting, Properties of the Integers: Mathematical Induction; Relations and Functions, Order (Posets, lattices, Moebius inversion) ; The Principle of Inclusion and Exclusion ; Generating Functions ; Recurrence Relations

Module II: Introduction to Graph Theory **- G**raphs and Simple Graphs- Subgraphs – Graph Isomorphism – Automorphisms – Vertex-Transitivity -Graph Representation- The Adjacency Matrix – The Incidence Matrix – Subgraphs – Vertex Degrees – Paths and Connection – Cycles – Trees and Forests – Planar Graphs - Graph Invariants – The No-Homomorphism Lemma

Module III: Distance,Centrality and Connectivity in Graphs - The Shortest Path Problem – Sperner's Lemma - Graphs as Models – Paths and Connectedness – Cut nodes and Blocks – Graph Classes and Graph Operations - The Center and Eccentricity – Self-Centered Graphs – The Median – Central Paths – Other Generalized Centers - Connectivity and Edge-Connectivity – Menger's Theorem - Properties of n-Connected Graphs – Circulants - Radius – Small Diameter – Diameter – Long Paths and Long Cycles - The Distance Matrix-The Eccentric Sequence – Distance Sequences – The Distance Distribution – Path Sequences – Other Sequences -

Module IV: Algorithms and complexity theory - Polynomial Algorithms and NP-Completeness – Path Algorithms – Maximum Matchings – The Max-Flow Min-Cut Theorem – Minimum Spanning Trees – Travelling Salesman Problem - Shortest Paths – Centers –

Module V: Mathematical logic and proof- Connectives, Tautologies, Valid Arguments, Derivation Rules, Deduction, Quantifiers and Predicates, Validity, Universal Instantiation and Generalization, Existential Instantiation and Generalization.

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage

References

- Ralph P. Grimaldi, Discrete and Combinatorial Mathematics, Fifth edition, Addison-Wesley, 2003.

- Harary and Buckley , Distances in Graphs, Addison-Wesley Longman
- Douglas B West,Introduction to Graph Theory,PHI Publishers, 2000

Semester : I
Course Code : FUS-713(x)
Course Title : Econometrics and Economic Forecasting
Credits : 4

Aim: The course intends to provide a comprehensive introduction to econometric concepts and techniques.

Objectives: The objective of the course is for the student to learn how to conduct and to critique empirical studies in economics and related fields. Although the emphasis of the course is on empirical applications, a treatment of traditional econometrics will also be made.

Module I: Nature and Scope of Econometrics, Statistical Concepts: Normal distribution; chi-sq, t- and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses, Simple Linear Regression Model: Two Variable Case - Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

Module II: Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R^2 and adjusted R^2 - partial regression coefficients; testing hypotheses - Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation, Specification Analysis - Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

Module III: Dummy variable technique – Use of dummy variables, regression with dummy variables – ANOVA models, ANCOVA models, interaction effects, piecewise regression, deseasonalisation, Logit, probit and Tobit models.

Module IV: Forecasting using Time series models: Smoothing and Extrapolation of Time series – Simple extrapolation models, Smoothing and seasonal adjustment. Properties of stochastic Time series: Introduction to stochastic time series models. Stationary and Non stationary Time series, Linear Timer Series Models. Moving average models, ARIMA Models and Specification of ARIMA models.

Module V: Application of Statistical Packages

End-Semester Assessment:
This will be through a written exam of three hours duration of 100 % weightage.

References

- Christian Gourieroux, Econometric of Qualitative Dependent Variables, Cambridge University Press, 2000.
- Christopher Dougherty, Introduction to Econometrics, Oxford University Press, 3rd edition, Indian Edition, 2007.
- Greene, W. H., Econometric Analysis, Prentice Hall.Goldberger, A., A Course in Econometrics, Harvard University Press, 2003.
- Gujarati, D. N. and D.C. Porter, Essentials of Econometrics, McGraw Hill, 4th edition, International Edition, 2009.
- Jan Kmenta, Elements of Econometrics, Indian Reprint, Khosla Publishing House, 2nd edition, 2008

- Kerry Patterson, An Introduction to Applied Econometrics: A time series Approach, Macmillan Press, London 2000.
- Krishna, K.L. Econometric Applications in India, OUP, New Delhi 1999.
- Robert. S.Pindiyck& Daniel Rubinfield, Econometric Models and Economic Forecasts, MacGraw Hill, 1998.
- Ruud, P., An Introduction to Classical Econometric Theory, Oxford University Press,2000.
- Stock, J.H. and M.W. Watson, *Introduction to Econometrics* (first edition), Addison-Wesley, 2003
- Walter Enders, Applied Econometric Time Series, 2nd Edn., Wiley, 2008.
- Wooldridge, J.M., *Introductory Econometrics*, South-Western College Publishing,2008

Semester : II
Course Code : FUS-721
Course Title : Dissertation
Credits : 20

Aim: The aim of the dissertation is to identify the topic and problem for the dissertation.

Objectives: The specific objectives are

- To discover and pursue a unique topic of research in order to construct new knowledge
- To design and conduct an original research project
- To develop skills in designing a discipline specific research methodology.
- To develop a working knowledge of relevant literature in the discipline
- To practice scientific writing and learn how to participate in the peer review process
- To be able to discuss research and other topics with academics in your field

Assign the student to develop a research plan and schedule for the semester/session and use this plan as the basis for assignments and assessment of the student's performance.

An exhaustive review of literature is to be done and place the problem suitably in the overall realm of research arena so that the exact gap identified. The student should have a clear idea of the objectives, tools and methodology for the problem at hand.

The research report must contain the detailed procedures for data collection/ survey/methods, theory and tools to be developed. The student should present the results/output and analysis of the study before finalizing the report. The final report is to be prepared by incorporating the suggestions after the presentations.