DEPARTMENT OF FUTURES STUDIES

UNIVERSITY OF KERALA

M.Phil PROGRAMME IN FUTURES STUDIES

SYLLABUS

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

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


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

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 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:
- 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
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, Schrödinger 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

- 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 molecular orbital 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 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, molecular docking, scoring functions, structure based de novo Ligand design, quantitative structure activity relationship QSAR, QSPRs methodology, various descriptors quantum chemical . use of geneticalgorithms, 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.

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 $\mathbb{R}^n$ Sequences and Limits, Subsequences and Limit Points, Cauchy Sequences and Completeness, Suprema, Infima, Maxima, Minima, Monotone Sequence in $\mathbb{R}$, 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 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,


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

References
- C. Mohan, Kusum Deep, Optimization Techniques, New Age Science, 2009
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
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
- D. K. Jha, Computational Physics, Discovery publishing House, 2009
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 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,


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

References

- Michael S. Waterman, Introduction to Computational Biology : Maps, Sequences and genomes, Chapmann& Hall/CRC 1995
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

- HamdyTaha, Operations Research, PHI, 2009
- George Bernard Dantzig and MukundNarainThapa, Linear programming: theory and extensions 1& 2, Springer, 2017
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 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
- Harary and Buckley, Distances in Graphs, Addison-Wesley Longman
- Douglas B West, Introduction to Graph Theory, PHI Publishers, 2000
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 V: Application of Statistical Packages

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

References
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.