

Ph.D. Prospectus
Center for Computer Studies Institute of
Business Administration
Karachi

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Disclaimer: IBA reserves the right to revise the contents of this prospectus without prior notice. You are advised to refer to the CCS program office for the latest information.

I. Introduction

The IBA Center for Computer Studies (CCS) of the Institute of Business Administration is offering graduate studies leading to PhD degree in the areas of Computer Science and Engineering (CSE), Information and Communication Technology (ICT), Operations Research, Artificial Intelligence, Cryptography, Numerical Analysis and Numerical Computing.

The CCS PhD program aims at encouraging those graduate students who can make a significant contribution to their field through original research. The various stages in the program are meant to ensure a thorough knowledge of their broader discipline. Quantitative and qualitative research capabilities are encouraged and interdisciplinary research along with interaction with the local industry is considered very positively.

The CCS PhD program motivates independence and originality of thought in the research process. The PhD program at IBA expects that not only will graduates display excellence in their field of research but that the discipline, research and professional competences they develop from their program will be very highly regarded by national and international employers. To achieve this, students are expected to immerse themselves in research in order to develop a strong and vibrant research culture at the institute.

II. Admission Requirements

1. Eligibility

Applications for admissions to PhD program shall be evaluated on an individual basis by the *Post Graduate Research Coordination Committee* (PGRCC) using the following criteria:

Academic Record:

- M.Phil or MS in relevant subject from HEC recognized local/foreign university, with minimum 3.0 out of 4.0 GPA.
- 18 years of education.

Additional Requirements:

- Two references from the institute/university last attended.
- Submission of GRE General test scores
- Brief proposal indicating research interests

All equivalence claims shall only be accepted after approval by the Higher Education Commission.

2. Test / Interview

All candidates will have to pass the IBA entrance test. The entrance test will comprise of a general graduate admission test which will test the applicant's abilities in Mathematics, English, General Knowledge and IQ. This part of the test will be common with the IBA MBA MIS admissions test. Additionally a subject test will be carried out for the PhD applicants in the field of computing and mathematics. The above tests will consist of multiple choice questions only.

3. Fee and Financial Aid

PhD students are entitled to full waiver of tuition fee for the entire program. A monthly stipend may also be given to the PhD students during the course work and residency period. PhD candidates shall be required either to act as a Research Associate to a Professor or to be Teaching Assistants and teach up to two undergraduate courses at the discretion of the Chairman of the department.

III. Doctoral Requirements

For completion of the PhD degree all candidates must satisfy the requirement given below, within a minimum of 3 years and a maximum of 6 years.

1. Credit and Residency Requirements

A total of 36 credits must be earned comprising of the following:

| | |
|----------------------|-----------|
| Course work credits | 24 |
| Dissertation credits | 12 |
| Total Credits | 36 |

It is recommended that the course work credits should be completed during the first 3 semesters after admission to the program.

Course work credits must be earned from courses offered by the IBA CCS. The students can take a maximum of 12 credits hours during each semester. The courses selected by the candidates for PhD course work should be taken according to the following course level distribution:

| | |
|--------------------------|--------------------------------------|
| 500 Level courses | 600 Level (or higher) Courses |
| maximum credits | minimum credits |
| 6 | 18 |

A PhD student must register for a minimum of 3 credits per semester until successful Doctoral Defense. The entire PhD program is meant primarily for full-time students only. Credits are not transferable to the IBA PhD program. Students having a GPA below 2.80 during PhD course work shall be put on probation. Other IBA standard rules for students on probation shall apply.

2. GRE (International) Subject Test

All PhD students also have to pass subject GRE (International) test¹. This test has to be cleared so that the candidate can be accepted as a Doctoral Candidate. If a GRE subject test is not available in the student's selected area, a replacement to this test may be devised by the IBA with approval from the Higher Education Commission. A student who has successfully passed the GRE subject test will be formally accepted as a *Doctoral Candidate*.

3. PhD Comprehensive Exam

All Doctoral Candidates must pass the PhD Comprehensive Exam within three years of admission to the PhD program. The PhD Comprehensive Examination will constitute

¹ Students admitted in August 2005 and who have cleared the IBA qualifying exam are exempt from the GRE subject test.

satisfactory progress and successful presentation of preliminary doctoral research conducted during the first three years of doctoral studies.

The PhD Comprehensive Examination will be conducted by the Doctoral Committee. The PGRCC may invite other experts in the field to the PhD Comprehensive Exam. A maximum of two attempts will be allowed for the Comprehensive Examination.

4. Research Papers

PhD candidates must have their research conducted at IBA (as part of their Dissertation credits) accepted by two internationally refereed journals that have been approved by the Dissertation Committee. The research papers must be accepted prior to the Dissertation Defense.

5. Dissertation Defense

After successful completion of the doctoral research, the candidate will be asked by the Doctoral Committee to present the draft of the PhD Dissertation to the Doctoral Committee in the prescribed format.

After approval of the PhD dissertation draft by the Doctoral Committee, the PhD dissertation draft will be sent to two overseas external examiners, to be selected by the Doctoral Committee, for approval. After the approval of the PhD dissertation by the external examiners, the candidate will be asked to appear for his PhD dissertation defense by making a formal presentation of his PhD dissertation to the Doctoral Committee. The PGRCC may invite other experts in the field to the final examination. After the Dissertation Defense, the Doctoral Committee may require changes to be incorporated by the doctoral candidates within a specific amount of time and to be resubmitted to the Doctoral Committee for final approval.

6. Summary

The PhD degree is awarded after candidates have satisfied the Doctoral Committee that their thesis is a substantial original contribution to knowledge and have also demonstrated a high degree of competence in areas of knowledge related to their specialization.

The overall requirements for the PhD degree are summarized as follows:

- Satisfactory completion of graduate-level courses with an overall CGPA of at least 2.8/4.0.
- Satisfactory performance in GRE subject test, based on HEC guidelines.
- Satisfactory performance in Comprehensive Examination.
- Acceptance of research work in 2 internationally refereed journals
- Submission and defense of a thesis, embodying the results of original research

IV. PhD Program Committees and Doctoral Faculty

1. Supervision of PhD work

The PhD study shall be supervised by the Dissertation Committee, which will comprise of two PhD faculty-members along with PhD candidates advisor who shall act as the convener to the committee. The candidate shall be advised on courses work and the dissertation work mainly by the advisor while other members of the Dissertation Committee may also be consulted. The candidate shall have to finalize the scope of dissertation work within the first twelve months of admission to the PhD program.

PhD Program Committees

a. Doctoral Committee

The purpose of the Doctoral Committee is to conduct the Comprehensive Exam; bring the dissertation to a prescribed level and format and to have the Dissertation Defense conducted for each PhD candidate.

b. Dissertation Committee

Separate Dissertation Committees are formulated for each Doctoral Candidate that are responsible to look after the progress of individual PhD students. It comprises of three PhD faculty members of the respective departments including the advisor of the candidate who shall be the convener of the Dissertation Committee. The Dissertation Committee is entrusted to advise the PhD candidates on all academic matters. The Dissertation Committee is formed by the Doctoral Committee on the recommendation of the Postgraduate Research Coordination Committee.

The processes to form the Dissertation Committee must be initiated by the PhD student by selecting a PhD advisor who must be a full time faculty at the IBA CCS.

2. Full-time PhD Faculty at the IBA CCS

Following is a partial list of PhD faculty at the IBA CCS with a brief profile. Further details of research conducted by the faculty are also available on the IBA website www.iba.edu.pk.

Dr. Ahmed A. Shah

Dr. Ahmed Ali Shah obtained his M. Sc. (Applied Mathematics & Statistics) from Karachi University and Ph. D. (Numerical Analysis) from the University of Kent at Canterbury, England under C. O. T. Scholarship of Government of Pakistan.. He has more than 25 years experience of teaching of Mathematics, Business Mathematics, Operations Research, Statistics and Computer Applications in England, South Asia and South East Asian Countries. Dr. Shah's strong research interests in the field of Numerical Analysis are the study of differential equations, numerical integration, design of algorithms and their applications in Computer Science and Business Development Strategies. He has successfully designed packages namely OAHM, GRSIM and GSMNSEM for the solution of non-symmetric systems of linear equations. The Codes are written in FORTRAN and are published in International Journals of Numerical Analysis. **Areas of interest: Numerical Analysis, Numerical Computing, Cryptography.**

Dr. Nasir Touheed

Dr. Touheed is Professor at the IBA CCS, and has a Ph.D from University of Leeds, England, UK; He also has a M.Sc in Applied Mathematics, University of Karachi and a M.A in Mathematics, and MS in Operations Research, University of California, Los Angeles. Dr. Touheed has worked as an Associate Professor and the Chairman of the Department of Computer Science, Karachi University. He has more than thirty two years of teaching experience at the University of Karachi. He is presently member of the IBA Board of Governors. Dr. Touheed is the author of 10 research publications, and is currently also a member of the Ph.D Steering Committee looking after the Ph.D program at IBA. **His area of research include Parallel Processing, Operations Research, Numerical Analysis, Data Warehousing and Data Mining.**

Dr. Sajjad Haider

Dr. Haider received his MS and PhD in Information Systems and Information Technology from George Mason University in 2002 and 2005 respectively. He has an MCS in Computer Science and B.Sc. (Hons.) in Statistics from University of Karachi. During 2005 to 2007 Dr. Haider worked for Fannie Mae as a Consultant in Predictive Analytics in the US. His research dissertation was on finding effective courses of action in dynamics uncertain situations. Dr. Haider has published over 18 papers in international journals and conferences. He is also the recipient of best paper awards for six years from the International Council on Systems Engineering (INCOSE) and also achieved first class first position during his B.Sc. **His research interests are in the areas of Artificial Intelligence and Bayesian Networks.**

Dr. Sayeed Ghani

After graduation from MIT, Dr. Ghani completed his M.S. and PhD. From Columbia University in Electrical Engineering, with specialization in the field of Telecommunications and a dissertation on modeling of Broadband Multimedia networks. Dr. Ghani had over 12 years of Data Communications and Telecommunications experience prior to joining the Institute of Business Administration, where he is presently chairman of the Centre for Computer Studies (CCS) and has also been a member of IBA's Board of Governors. Prior to this he has worked as Member of Technical Staff at NYNEX Science & Technology, in New York, where he was heavily involved in the Standards process of high-speed data services (SMDS, IEEE 802.6) and ATM networks. He has worked at GTE Labs and at the Lab for Computer Science at MIT. Dr. Ghani has also worked for various organizations including ABN AMRO Bank, State Life Insurance Corporation of Pakistan and Lever Brothers in Pakistan. He has also been Project Manager and subsequently General Manager Engineering for a leading data communications service provider and ISP in Pakistan, responsible for introducing VSAT and X.25/Frame Relay services in Pakistan. He also served as Director Telecommunications, NewCore Networks, a California based company, working on the design of Next Generation Multimedia switching equipment. Dr. Ghani is also the recipient of the best teacher award from Sindh for 2007 conferred by the Prime Minister of Pakistan in the Salam Teacher Day awards. **His research interests include performance analysis and simulation of wireless, 4G and heterogeneous networks.**

Dr. Wasim A. Khan

Dr. Wasim A. Khan obtained PhD in Operations Research form University of Sheffield, England, U.K in 1990. After his graduation he remained involved in teaching and research at leading institutes of Pakistan including Ghulam Ishaq Khan Institute of Engineering Science & Technology, National University of Science & Technology (NUST) and Karachi Institute of Information Technology (KIIT). He remained associated

with Crescent Software (CresSoft) for two years and has vast experience of software project management in Tick-IT environment. He has several research publications to his credit. Dr. Khan is a chartered engineer of engineering council (UK), a corporate member of Institute of Mechanical Engineer (IMechE), UK, Corporate member of Institution of Electrical and Electronics Engineers (IEEE), USA, and a member of IEEE Computer Society. In November 2007, Dr. Khan achieved the prestigious status of Fellow of the Institution of Mechanical Engineers (FIMechE). He is author of several research papers and books published by international publishers. **His areas of special interest include Operations Research, Virtual Manufacturing and Education Management.**

3. Other IBA Faculty

Other IBA faculty members having cross-disciplinary relationship with CCS include the following.

Dr. M. Nishat

Dr. Nishat is Professor and Chairman, Finance and Economics at IBA. He holds a Ph.D. in Economics (specialization in finance) from Auckland Business School, University of Auckland, New Zealand and a Masters in Management Sciences and Economics from the University of Waterloo, Ontario, Canada. Prior to this he was research Professor and In-charge of graduate students at the Applied Economics Research Center, University of Karachi. He was also the Project and CO-project leader with teams deputed on research studies awarded to the Applied Economics Research Center by international institutions like the World Bank, the Harvard Institute of International Development, IFPRI as well as federal, provincial and local government bodies. He was awarded the Best Teaching Award by the Department of Economics at the University of Auckland in 1994. He is a prolific author with 18 research articles in Pakistan and foreign professional journals. He is also a regular contributor to national dailies and guest speaker at Pakistan Naval Academy Staff College, Institute of Bankers and NGOs in Karachi.

Dr. Qazi Masood

Dr. Masood completed his Ph.D. from the Center for Fiscal Studies, Bath, England in 1997. He has ten years of experience in research and consulting in the fields of Public Finance, Agriculture and Trade. He teaches postgraduate courses in Public Finance and Macroeconomics. He has undertaken assignments for several national and international agencies in Public Finance and Policy, Regional Economics and other related fields. He has 16 publications in international and national journals in the fields of Monetary Economics and in Public Finance. Dr. Masood has been associated with the Government of Pakistan in different capacities such as the Resource Person, Mobilization and Tax Reforms Commission, and the member of Task Force, the Tariff Reforms Commission.

Dr. Shahid Mir

Dr. Mir holds a B.E. (Elects.), And a Ph.D. in Management from Adamson University (Philippines). He has also done technical and management courses from France. He has more than 15 years of working experience both in public and private sector Organizations. Dr. Shahid Mir is a life member of the Royal Aeronautical Society (UK). He is also an ISO 9000 lead auditor. Dr. Mir's areas of teaching include Research Methodology, Material Management, Marketing Management and other Management courses.

V. PhD Courses Description

Following is a partial list of courses relevant to the PhD program.

1. General

GEN345 (3,1,4)¹ Research and Evaluation Methods

Research, experimental, and statistical methods; Development of skills and knowledge for conducting original research, critically evaluating empirical studies. Various research designs and data collection techniques; Focus on computerizing data sets for quantitative analysis, analyzing strength of relationships, selecting appropriate statistical techniques, and testing statistical hypotheses; The scientific method; research/design requirements and objectives: quantitative, and case studies; performance metrics; design procedures and control; sources of error and bias; evaluation tools; formal validation methods; documentation standards.

2. Information and Communication Technology (ICT)

ICT552 Computer Communication Networks – I

Architecture of network protocols and performance evaluation of networks. Students are expected to have a strong mathematical background and an understanding of probability theory. Topics discussed will include: layered protocols, data link layer, transport layer, high-speed packet switching, queuing theory, Local, Metropolitan and Wide Area Networking; flow and congestion control and routing. Prerequisites: CSE243 or equivalent; introductory probability course.

ICT650 Wireless and Mobile Networking – I

Architecture and design of cellular systems with emphasis on support of high-speed wireless data, and high-performance packet radio networks. Overview of mobile and wireless networking, fundamental concepts in mobile wireless systems: propagation and fading, cellular systems, channel assignment, handoff. Third and Fourth Generation cellular networks. The course will also focus on research issues in multiple access techniques, cellular system design, and ad-hoc wireless networking. Prerequisites: ICT552 or ICT651.

ICT651 Computer Communication Network & Simulation

Focus on issues concerned with Broadband networks and protocols; ATM. Traffic characterization and modeling: Markov-modulated Poisson and Fluid Flow processes; application to voice, video, and images. Traffic Management in ATM networks: admission and access control, flow control. ATM switch architectures; input/output queuing. Quality of service (QoS) concepts.

Prerequisites: ICT552 or ICT651.

ICT652 Topics in Communication Networks

This is an advanced PhD level course that focuses on research issues in data and telecommunications networks. Students taking this course must already have selected their PhD research topics and will be required to present their ongoing research in a series of presentations. Discussions will be focused around individual research topics and literature review. The objective of the course shall be to cover in depth individual research topics and to develop these into publishable research. Term and Final exams shall also be conducted based on topics of common interest.

ICT657 Modeling and Simulation of Networks

This is an advanced PhD level course focusing on developing working models of network protocols for research purposes and writing simulation code of these protocols. Students taking this course must already have selected their PhD research topics and will be required to present their ongoing research simulations along with their results in a series of presentations. Discussions will be focused on modeling, implementing and simulating protocols based on individual student research areas. The objective of the course shall be to create simulations of their proposed network protocols and to convert the results into publishable research. Term and Final exams shall also be conducted based on modeling and simulation topics of common interest. Prerequisites: ICT552 or ICT651.

ICT655 Information Assurance

Advanced topics in information assurance, including selections from the following: penetration testing, formal verification of systems, formal models of information flow and protection, distributed system authentication, protocol design and attack, computer viruses and malware, intrusion and anomaly detection models, multi-level security, active defenses, investigation and forensics, network firewalls, anonymity and identity, e-commerce support, and database security models and mechanisms; Also current research and developments in information assurance.

ICT656 Technology and Telecommunication Policy

National and international policy issues that from the interaction between scientific and technological development in the telecommunication industry and government policies; Telecommunication policies in developed countries and its impact on technological and infrastructure development; Comparing telecommunication policy of China and US.

3. Management Information Systems (MIS)

MIS501 Management of Information and Systems Security

Development and management of effective security systems; Includes information, personnel, and physical security; Emphasis on risk analysis for information protection.

MIS502 Planning for Disaster and Managing Recovery of IS

Disaster recovery planning and business continuity; Recovery of information and communication systems; Establishing and managing computer emergency response teams, handling information technology crises and emergencies; planning for business continuity; and recovering from IT emergencies.

Prerequisites: MIS501

MIS602 Info Technology for Crises and Emergency Management

Concepts and problems of crises and emergency management; Defining crises, emergencies, and disasters; Developing crises and contingency plans; The role of information in crises and emergency management; determining disaster and crises information requirements; information technologies applied to crises, disaster, and emergency management; causes and effects of information breakdowns during crises and disasters.

Prerequisites: MIS502

MIS601 A Strategic Approach to Information Systems

Policies and guidelines that govern the arrangement of IT tools and data; Issues related to the establishment of a logical, coherent plan for decisions about technology investments; System compatibility, interconnection, and integration.

MIS603 Managing E-Commerce Technologies

Principles of good-e-business management; Methods of conducting e-commerce-major opportunities, limitations, issues, and risks; Popular technologies for building e-businesses, security authentication, privacy, acceptable use policies, and legal limits.

MIS604 The Learning Enterprise

Social engineering and organizational dynamics that support business transformation, leading to the ultimate “learning organization”. Cultural change and learning strategies that impact the enterprise’s efficiency, effectiveness, and innovation.

Prerequisites: MIS601

MIS605 Adaptive Learning Systems

Learning as an alternative to rule-based schemes for artificial intelligence; Deterministic and probabilistic simulation of games; Markovian and bounded-context systems; The algedonic process; Introduction to collective learning systems theory; Design, simulation, and evaluation of collective learning automata; Alternative memory structures; Selection and modification policies; Environmental models and evaluation policies; Metrics for performance evaluation of collective learning systems automata; Self-organizing, hierarchical networks of collective learning cells.

MIS651 E-Government

Tools and techniques for designing and managing e-government projects; essential building blocks for e-government. Technology infrastructure for enabling e-government; Various technologies and their role in developing, procuring, commissioning, and implementing e-government solutions; Key enablers for e-government; E-government and public-private partnerships; E-solutions in government-the change management issues; Accounting, auditing and risks of introducing e-government applications and solutions; Security issues and current government security policies for ICTs and e-government; Examples and case studies of electronic government in the world and in Pakistan.

Prerequisites: MIS601

4. Computer Science and Engineering (CSE)**CSE601 Embedded Systems**

Fundamentals of distributed system architecture, design approaches, real-time embedded networks, system-wide scheduling and dependable system design; Embedded systems with multiple, distributed processing elements connected by a real-time network; Applications in areas of transportation, medical equipment, industrial control, and household appliances.

CSE602 Virtual Reality

Programming for 3D graphics, animation and virtual reality applications; Current topics in computer animation and virtual reality; Computing hardware and peripheral devices.

Prerequisites: CSE601

CSE603 Human-Factor Engineering

The human factors of interactive computing; fundamentals of cognitive psychology, linguistics, computer science, and management science applied to the design and development of interactive computer systems: user modeling, requirements analysis, human-computer interface design, new systems implementation.

Prerequisites: CSE602

CSE604 Parallel Algorithms

Design and analysis of parallel algorithms; shared-and distributed-memory parallel computation models, graph algorithms, divide-and-conquer algorithms, numerical problems; parallel algorithms for combinatorial optimization.

Prerequisites: CSE651

5. Mathematics and Statistics (MTS)

MTS501 Introduction to Linear Algebra and Multivariable Calculus

Introduction to linear algebra, including vectors, matrices, and applications; Calculus of functions of several variables, including partial derivatives, constrained and unconstrained optimization, and applications.

Prerequisites: MTS203.

MTS502 Introduction to Mathematical Logic

An introduction to mathematical logic with applications to computer science and algebra. Formal languages; Completeness and completeness of first order logic; Definability and interpolation; Decidability. Unsolvable problems; Computable functions and Turing machines; Recursively enumerable sets; Transfinite induction.

Prerequisites: MTS201

MTS601 Methods of Discrete Mathematics

Finite groups, finite fields, finite geometry, discrete probability, and graph theory; A unifying theme of the course is the symmetry group of the regular icosahedron, whose elements can be realized as permutations, as linear transformations of vector spaces over finite fields, as collineations of a finite plane, or as vertices of a graph.

Prerequisites: MTS502

MTS602 Functions of Complex Variable

The convergence of infinite series; functions of a complex variable; Cauchy's theorem; uniform convergence; the calculus of residues; integral functions; conformal representation; the gamma function; the hypergeometric functions; Legendre Functions; Bessel Functions; the Elliptic Functions of weierstrass; Jacobi's elliptic functions.

Prerequisites: MTS203 with instructor's permission.

MTS603 Mathematical Probability

Probability theory; Discrete and continuous random variables; distribution and density functions for one and two random variables; conditional probability; Generating functions, weak and strong laws of large numbers, and the central limit theorem; Geometrical probability, elements of random processes: the Poisson process, random walks, and Markov chains.

Prerequisites: MTS202

MTS604 Applied Differential Equations

Analytic, Numerical, and qualitative analysis of ordinary differential equations, Linear equations, linear and non-linear systems; Application to mechanics, biology, physics, and the social sciences; Existence and uniqueness of solution and visual analysis using computer graphics; Topics selected from Laplace transforms, power series solutions, chaos, and numerical solutions.

Prerequisites: CSE202

MTS605 System Integration and Validation

Overview of the systems engineering activities; Planning and design of complex systems from continuous to discrete time; Synthesis of systems methodology; State estimation. Parameters identification; Discretization and stochastic effect; Dynamic, logic control. Modeling; discrete event, simulation examples; Synthesis of solutions; integration of knowledge and requirements; verification and validation of the system; Strategies for designing, integrating, testing, and validating products and systems.

Prerequisites: CSE241 or the instructor's permission.

MTS606 Numerical Analysis

Interactive methods, Differences; The solution of linear simultaneous equations; Roots of polynomial equations; Linear interpolation; Numerical integration; Iterative methods for the solution of Nonlinear Equations; The Solution of Differential Equations; Boundary-value Problems in Differential Equations.

Prerequisites: CSE202

MTS607 Optimization

System Models; Optimization Problems; Optimization Techniques; Functions, Regions and Optimization; Functions of a single Variables – Analytical Methods; Functions of a single Variable – Numerical Methods; Multivariable Search-Analytical Methods; Multivariable Search-Numerical Methods; Functions of a Continuous Variable-Analytical methods; Functions of a Continuous Variable-Numerical methods.

Prerequisites: CSE202 or instructor's permission.

MTS653 Time Series Analysis and Forecasting Methods

Introduction and definition of time series; Box-Jenkins approach to time series models; Identification of tentative model; Estimation and diagnostic checking of fitted model, Forecasting. Time series regression; Classical regression model and its estimation; Prediction using regression model; Exponential smoothing and its use in forecasting.

Prerequisites: MTS103, MTS102, MTS202

ECO651 Advanced Econometrics

The general linear statistical model: Specification of the model, Point estimation. The Normal general linear statistical model: Maximum likelihood estimator, Interval estimation, hypothesis testing. Simultaneous linear statistical model: Introduction, Specification of the sampling model, Least square bias, Estimation of the reduced form parameters, From reduced form parameters to structural parameters, Model formulation Problem of heteroscedasticity and autocorrelation in econometric models. Pooling data and varying parameter models : Models for time series and cross-sectional data, Varying parameter model.

Prerequisites: MTS103, MTS102, MTS202

MTS652 Multivariate Statistical Methods

Basic statistical concepts and introduction to multivariate analysis, Matrix algebra, Samples from multivariate normal population : Introduction, Multidimensional random variables, The multivariate normal distribution ,Conditional and marginal distributions of multinormal variates, Samples from the multinormal populations, Correlation and regression, Simultaneous inferences about regression coefficients and correlation matrix. Tests of hypothesis on means.

Prerequisites: MTS103, MTS102, MTS202

MTS651 Statistical Data Analysis

Introduction of statistical packages, How to use statistical techniques, Fitting of binomial and other distributions to observed data, Comparing two treatments, Statistical

dependence and independence and the random sampling model, Randomization and blocking with paired comparisons, Significance tests and confidence intervals for means, variances, proportions and frequencies , Comparing more than two treatments, building models and using them.

Prerequisites: MTS103, MTS102, MTS202

MTS654 Regression Modeling

Linear regression and residual analysis; Extending the linear model to include multiple predictors; Model building using computer aided selection techniques (backward elimination, forward selection, stepwise, best subsets); Correlation Analysis. Zero order correlations (Pearson, Kendall, Spearman) and partial correlations; Confidence intervals and tests of hypothesis for coefficient of a correlation (Fisher's z test).

Prerequisites: MTS202, MTS501, MTS603

MTS655 Categorical Data Analysis

Statistical inference for two and three way contingency tables; odds ratio and other qualitative measures of association, binary response models and logistic regression; associations in log linear models; fitting log linear and logit models; generalized linear models.

Prerequisite: MTS654

MTS656 Data Analysis and Modeling

Developing the ability to collect information and to use information technology to analyze statistically and draw conclusions; Inference about location and scale parameters, goodness of fit test, non parametric tests; Developing computer skills to solve problems for univariate and multivariate data, regression, ANOVA, principal component, factor analysis, Time series analysis.

Prerequisite: MTS655

MTS657 Design and Analysis of Experiments

Advantages of designed experiments in engineering and science; The "one-factor-at-a-time" approach to experimentation; Randomization, replication, blocking and balancing; Full and fractional factorial experiments and their analysis; Main effects and interaction effects; Use of normal and half-normal plots, confounding; Composite and sequential designs; Response surface designs and their analysis.

Prerequisites: MTS654

MTS658 Multivariate Data Analysis

Applied Multivariate Methods; Introduction to Matrix algebra, Design matrix, quadratic forms, transformations, orthogonal matrices; Bivariate discrete and continuous distributions, multivariate normal distribution; Principal Components Analysis, Factor Analysis, Discriminant Analysis, Cluster Analysis, Profile analysis, Multi scaling problem.

Prerequisite: MTS656

MTS659 Stochastic Models

Review of probability distributions and random variables, followed by selected topics from stochastic processes and their application; possible topics include Bernoulli, Poisson, Markov, and renewal processes, queuing theory, computational probability, simulation, and stochastic dynamic programming.

Prerequisite: MTS604, MTS 603

VI. Research Facilities for PhD Students

1. IT Infrastructure

The IT infrastructure has in the recent past been improved considerably with addition of over 400 state of the art PCs, a high speed Internet with a bandwidth of 4 Mbps, and a fully deployed wireless LAN across both the campuses.

2. IBA Intranet

An IBA Intranet has been created which provides numerous useful links to students and faculty at IBA. These include links to over 17,000 research journals (available via HEC digital library program), 40,000 e-books, a fully automated Library Management System (LMS), an IBA Research Portal (IRP), a Campus Management System (CMS) among other sites.

3. IBA Research Portal (IRP)

The IBA Research Portal is accessible via the IBA intranet. At present over 350 papers written by IBA students and faculty have been put in the IRP, which provides a fully searchable and downloadable resource for all students and faculty at IBA.

4. New Library website and Virtual Library

A new library website and a virtual library website has been successfully launched. This is accessible from the main IBA website; the virtual library designated as the 'Online Resource Center' provides links to online databases, research reports, magazines, newspapers, online books and other useful reference sites world wide.

5. Telecommunications Research Lab (TRL)

A completely renovated TR Lab has been created for PhD level research with provision for running Linux based NS2 simulations for wireless networks at the City Campus.

6. ICICT Conference

A major International Conference on ICT is a key event to propagate research at IBA. This year the 1st International Conference on ICT (ICICT 2005) was first held on August 27, 28 in the Pearl Continental Hotel Karachi, and was inaugurated by the President of Pakistan. The ICICT 2005 was a fully reviewed, multi-topic, International Conference on ICT. Proceedings of the original research papers were also published and are also available via the IEEE international online database. A number of international delegates and prominent national speakers participated in this conference. This conference which is held once every two years had its second conference (ICICT2007) held in December 2007.

VII. Contact Us

For further information, please contact:

- Dr. Wasim Khan, HEC Professor, Center for Computer Studies, IBA, City Campus, Garden/Kiyanee Shaheed Road, Karachi-74400
- Tel: 111-677-677x31, E-Mail: info@iba.edu.pk, Website: www.iba.edu.pk