BMI Graduate Certificate Course Descriptions

**PREREQUISITES**

**Design & Analysis of Algorithms (CS4071)**

**Introduction to Functional Genomics (GNTD8001C)**
The course consists of lectures/seminars on the theory and use of functional genomics approaches in biomedical research. Each lecture is accompanied by a lab session in an electronic classroom that provides hands-on experience in practical application of functional genomics principles. A key part of the course is group research projects in which students analyze primary genomics data to answer research questions.

**CORE COURSES**

**Database Management Theory (EECE6010)**
Database formal architectures emphasizing modeling and theory. Formal methods for database architectures; relational, hierarchical, object, object-relational and network; data dependencies, normalization, integrity constraints, concurrency, heterogeneous systems.

**Introduction to Biostatistics (BE7022)**
Students will learn basic statistics such as mean, median, mode, standard deviation, variance, etc. Topics include probability, parametric statistics such as t tests and one way analysis of variance, and nonparametric statistics including both Wilcoxon tests and Kaplan-Meier estimation of survival. Bayes theorem, discrete (e.g. Binomial) and continuous probability distributions (e.g. normal distributions and one variable regression and product moment correlation and rank correlation are covered.

**Introduction to Medical Informatics (BMIN7053)**
Biomedical Informatics is an interdisciplinary field that combines knowledge of information sciences and medical sciences to optimize the use and application of biomedical data across the spectrum from molecules to individuals to populations. This course will present students with an introduction to the field of biomedical informatics through the use of core technologies and data science (computational and analytical methods) as it applies to clinical research and the use of health information technology to improve patient outcomes/healthcare delivery. Specific topics will include: overview of the field, data standards; security, confidentiality, regional health information exchange, standards, terminologies, database principles, data marts/data warehouses, interfaces and other topic as related to the healthcare and research setting. Learning objectives will be achieved using a variety of methods including: didactic lectures, group discussions, demonstrations, self-study, student projects, and selected readings from peer reviewed journal articles for each topic to develop critical analysis skills and ascertain real world applications.

**Introduction to Bioinformatics (BMIN7099)**
Introduction to Bioinformatics is a multidisciplinary, entry level graduate course, which is an extension of current BME643 course and aims at achieving a deeper understanding of central algorithmic problems and current computational methods used in the context of data rich biomedical research. Subjects covered include: deep sequencing, biological sequence analysis, statistical models for gene expression profiling, prediction of protein and macromolecular complexes structure and function, systems biology. Analysis of algorithmic aspects will be accompanied by projects and
case studies to provide a direct illustration of computational issues and to provide knowledge and practical command of standard bioinformatic tools and protocols that are being used to analyze complex biological data.

**Biomedical Informatics Seminar/Topics in BMI (BMN7003) (1 credit)**

**ELECTIVE COURSES (select 2)**

**Artificial Intelligence I (CS6033)**
The course will cover in detail the topics of state space search, game tree search, constraint satisfaction, logic based knowledge representation and reasoning, first order predicate calculus, uncertainty handling using Bayesian probability theory, and some applications of these techniques. Applications may be selected from the area s of automated planning, natural language processing, or machine learning.

**Computational Systems Biology (MCP6031C)**
This course introduces techniques for constructing computational and mathematical models of biological processes at several levels of organizational scales from different points of view-from genome to whole-tissue, and from static to dynamic. Students will hear lectures, read literature, participate in discussions focused on the various modeling techniques, and build computational models using standard tools. Students will learn: • Criteria for selecting modeling techniques suited for addressing biological questions • Quantitative characterization of biological properties (eg. robustness) • Basis for valid assumption and how complexity of problems in biology can be tackled Hands on experience will be a key component of this course. Students will also work in teams to complete group modeling projects that utilize the modeling techniques specific to the particular module. Student teams, consisting of 3-5 students, will be assembled so that they maintain diversity with respect to computational, mathematical, and biological knowledge and skills, and therefore, students will also teach one another as they work together on their team to complete their projects. Students will present their projects to the class.

**Digital Image Processing (EECE6042)**
Digital image foundation and characterization, discrete transforms, image enhancement, encoding, compression and restoration. Prerequisite: senior or graduate standing.

**Intelligent Data Analysis (CS6052)**
This course will introduce students to the theoretical and practical aspects of the field of data mining. Algorithms for data mining will be covered and their relationships with statistics, mathematics, and algorithm design foundations will be explored in detail.

**Advanced Algorithms I (CS7081)**
Advanced treatment of fundamental topics in algorithms that every graduate student should know and have some sophistication in. Knowledge and ability to apply the fundamental design strategies: the greedy method, divide-and-conquer, dynamic programming, to solve important problems in data encryption, efficient polynomial, integer, matrix multiplication, computing the Discrete Fourier transform, using the celebrated FFT algorithm, and so forth. In addition this course will introduce students to lower bound theory and NP-completeness.

**Principles of Clinical Trials (BE7066)**

**Introduction to Epidemiology (BE7076)**
The course introduces methodology for studies of the cause of disease in human populations. Topics that are covered are chronic disease, infectious disease, and occupational and environmental epidemiology. Sources, collection, handling, and interpretation of health data are also discussed.

**Clinical Decision and Cost-Effectiveness Analysis (BE7068C)**
Introduction to methods and applications of decision analysis and health economic analyses such as cost-effectiveness, and cost-benefit analyses in medical decision making. Key topics include the fundamentals of building decision models, Bayes' Theorem and the interpretation of diagnostic test results, patient preference-based utilities, design and assessment of economic analyses of health care, and advanced topics including Markov modeling, and Probabilistic Sensitivity Analysis using second order Monte Carlo modeling. The course format consists of a series of didactic lectures, workshops, and detailed clinical examples. Computer-based exercises are used during workshops, using decision modeling software [Decision Maker for Windows - WinDM®], and Excel™ spreadsheets. The culmination of the course is the development of a decision analytic application, usually a decision analysis. Many students have continued to work on their projects and have turned them into presentations at regional and national conferences and peer-reviewed publications.

**Applied Bayesian Analysis (STAT6043)**
Foundation of Bayesian Statistics, basic theory and several applications including Monte Carlo and Markov Chain Monte Carlo Methods for computing Bayesian inference will be covered. Specific topics include: Foundation of Bayesian Approach, Prior and Posterior distributions; Choice of Priors: subjective and non-subjective or default approaches; Inference using posterior distribution for standard models; and Hierarchical models, and their applications. WinBUGS will be introduced.

**Pattern Recognition (CS8021)**
The topics covered will include Statistical Pattern Recognition - its basics and applications, algorithms for clustering and their analysis. A flavour of different types of clustering algorithms will be given and a few algorithms will be studied in great depth. Relevance of all the above techniques for pattern discovery, classifier design, and dimensionality reduction will be investigated. A number of examples from real-life datasets will be examined in depth during the class presentations and by students during their homework assignments.

**Genetics of Complex Disease (BE8068)**
The course is designed to provide basic understandings of the inherited basis of complex diseases that involve both genetic and environmental factors. With an introduction of the principles of gene mapping and their applications in non-Mendelian traits, emphasis will be placed on changes in the paradigm with rapid developments in technologies and analytical approaches to identify genetic variants influencing the risk of common diseases. Lectures will cover topics on fundamental principles of heredity o Principles of population genetics, measures of genetic variation, Hardy-Weinberg Law o Genetic markers - RFLPs, SNPs, CNVs o Fundamentals in gene mapping: linkage and association, linkage disequilibrium, haplotypes o Non-Mendelian inheritance, complex disease o Evolving paradigm of complex disease genetics o Human genome project, HapMap, ENCODE project, 1000 Genome project o Genome-wide association studies o Statistical concepts - statistical significance, effect sizes, multiple testing, population substructure o Choice of population - isolated versus cosmopolitan populations in complex disease studies o Pathophysiology, natural history and genetics of few common diseases - obesity, type 2 diabetes, stroke.
Molecular and Cellular Biology (GNTD7001)
Primarily a lecture based course that represents the first course in the core curriculum series that is designed for all first year graduate students in the College of Medicine. Topics include DNA replication, recombination, and repair; Cell cycle regulation; Transcriptional regulation; Translational regulation; Protein trafficking; etc.

Data Warehouse Design (EECE8075)
Data warehouse design with conceptual data models and physical storage techniques; data mining techniques including clustering, pattern recognition, and data visualization.