Core Courses

**BMIN 7053 – Introduction to Medical Informatics (3 credit hours)**
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.

**BMIN 7054 – Data Science for Biomedical Research (3 credit hours)**
Data Science for Biomedical Research will cover statistical and data mining techniques that are essential for processing, analyzing and mining BigData, with the overarching goal of learning from data in order to gain useful predictions and insights.

**BMIN 7099 – Introduction to Bioinformatics (3 credit hours)**
Introduction to Bioinformatics is a multidisciplinary, entry level graduate 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 complex structure and function, and 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.

**BMIN 8001 – Biomedical Informatics Practicum (3 credit hours)**
The Biomedical Informatics Practicum is a project oriented course that combines the use of electronic medical records and other clinical informatics systems with research questions centered on Omics studies, personalized and preventive medicine, and quality of health care delivery. The projects will be designed to use state-of-the-art techniques and up to date data sets to identify current challenges develop solutions.

**BMIN 8089 – Dissertation Research (1-15 credit hours)**
Research tasks as advised by the dissertation adviser shall be completed.

**EECE 6010 – Database Management (3 credit hours)**
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.

**GNTD 7003 – Ethics in Research (1 credit hour)**
This course introduces students to ethical theories generally and the ethical and regulatory issues they are likely to encounter as researchers. Students will learn to identify issues, how to analyze ethical issues in research, and to develop coherent justifications for their ethical and responsible conduct of research.

**GNTD 8001C – Introduction to Functional Genomics (3 credit hours)**
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 provide 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.
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General Medical Sciences (Select Two Courses)

BE 7066 – Principles of Clinical Trials (3 credit hours)

BE 7068C – Decision and Cost-Effectiveness Analysis (3 credit hours)
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.

BE 7076 – Introduction to Epidemiology (2 credit hours)
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.

GNTD 7001 – Principles of Molecular and Cellular Biology (3-4 credit hours)
Principles of Molecular and Cellular Biology is designed primarily as a lecture-based course that will provide fundamental knowledge of the basic principles underpinning modern molecular and cell biology, with attention paid to the underlying biochemistry where relevant. It is anticipated that the material will be appropriate and applicable for all new first year students in the various doctoral programs of the College of Medicine, as well as many students enrolled in the College’s various master’s programs. A (non-exhaustive) list of topics to be covered in the course follows: Basic information on the range and types of biomolecules; DNA replication, recombination, and repair; Cell cycle regulation; Transcriptional regulation; Mendelian genetics; Chromatin structure and epigenetics; Basic genomics and bioinformatics; Translational regulation; Signal Transduction; Protein trafficking; Membranes, vesicles and sorting; Cell-cell interactions; Cytoskeleton: movement and polarity; Molecular motors; Cell death pathways.
Technical Electives (Select Four Courses)

BANA 7015 – Advanced Health Care Data Analytics, Business Intelligence and Reporting (3 credit hours)
This course teaches the use of healthcare data to make decisions and transform healthcare delivery and the health of individuals and populations. The course concentrates on big and small data, and structured and unstructured data. Tools, applications and approaches for health data analytics are taught. This course covers topics such as statistical approaches; data, web and text mining; data visualization, simulation, modeling and forecasting. Key regulatory health and healthcare reporting requirements are taught.

BE 7022 – Introduction to Biostatistics (3 credit hours)
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.

BE 7024 – Computational Statistics (3 credit hours)
SAS - Introduction; windows environment; techniques of entering data; importing data; creating permanent data sets; managing data; subsetting data sets; merging data sets; proc command; running SAS programs; analyzing counts and tables; analyzing quantitative data; creating graphs; controlling output. R - Downloading and installing R; packages; graphing facilities; getting data into R; downloading data sets into R from external sources; matrix function; data frame function; list function; managing subsets of data; sorting data; exporting data; loops and functions; analyzing counts and tables; analyzing quantitative data; panel data; Project - Analyze a specific internet health data.

BE 7070 – Qualitative and Quantitative Data Collection Methods for Health Services Research (2 credit hours)
In this course, students will learn concepts, methods, and practical procedures for developing and implementing quantitative and qualitative health survey instruments to answer their own research questions. Through hands-on learning, students will gain experience in instrument design and construction, sampling considerations, data collection methods, coding, processing (including automated methods), presentation, and data analysis. Each student will identify a health-related research question and design qualitative and quantitative instruments and methods for answering it. By Permission Only.

BE 7071 – Quality Improvement and Patient Safety (1 credit hour)
This course will cover the fundamentals of quality improvement and patient safety. It will use a framework of human factors to facilitate understanding complex system failures and successful strategies to reduce hazard in industrial and medical environments. The concepts are taught using a case-based format to explore common human and organizational sources of failure, such as missing or inert knowledge, communication/collaboration, clumsy technology, human computer interaction (alerts and reminders), and role of a safety culture. The second half of the course is devoted to learning approaches for implementing evidenced-based practices based on Rogers’ theory, where adopting innovation in an organization is divided into two major activities: initiation and implementation.

BE 7074 – Community-Based Participatory Research (1-3 credit hours)
This class is designed to familiarize learners with the theoretical framework, methodologies, and applications of community-based participatory research and how it differs from traditional research approaches and community-placed research.

BE 7080 – Analysis of Internet Health Data (3 credit hours)
Examples of internet data: Framingham Health Data; National Inpatient Sample; Nurses Health Data; Emergency Admissions Data; Pediatric Admissions Data. Description of data sets. Analysis of Inpatient Sample Data. R package for data analysis. New research projects.
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BE 8068 – Genetics of Complex Disease (2 credit hours)
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, principles of population genetics, measures of genetic variation, Hardy-Weinberg Law, Genetic markers, RFLPs, SNPs, CNVs, Fundamentals in gene mapping: linkage and association, linkage disequilibrium, haplotypes, Non-Mendelian inheritance, complex disease, Evolving paradigm of complex disease genetics, Human genome project, HapMap, ENCODE project, 1000 Genome project, Genome-wide association studies, Statistical concepts - statistical significance, effect sizes, multiple testing, population substructure, Choice of population - isolated versus cosmopolitan populations in complex disease studies, Pathophysiology, natural history and genetics of Pre-Requisite: To take this course you must: Have taken the following Courses 26BE776 min grade C/Pass, 15BIOL101 min grade C/Pass.

BME 6012 – Biomedical Signal and Image Processing (3 credit hours)
Fundamentals of signal and image processing, Fourier analysis, and stochastic processes, with emphasis on biomedical applications. Filtering transformation and feature extraction for biomedical signals.

BME 7061 – Biostatistics in Research (3 credit hours)
In this course a number of statistical methods will be presented to analyze various types of data stemming from research. A rudimentary knowledge of probability and inferential statistics will be assumed. How to evaluate a diagnostic test will be dealt with in depth. Analysis of contingency tables and log linear models will be presented to answer a number of relevant research questions. A detailed presentation of logistic regression and rudiments of Survival Analysis will be presented. Presentation of current research from journals.

BME 8064 – Advanced Statistical Methods in Biomedical Research (3 credit hours)
Summary statistics of multivariate data; principal components; factor analysis; multivariate analysis of variance; multivariate multiple regression; multidimensional scaling; heat maps; multivariate graphics; pattern recognition; cluster analysis; random forests Pre-Requisite: To take this course you must: Have taken the following Courses 20BME461 min grade B-, or BME4061 min grade B-.

CS 6033 – Artificial Intelligence (3 credit hours)
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 of automated planning, natural language processing, or machine learning.

CS 6052 – Intelligent Data Analysis (3 credit hours)
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.

CS 6065 – Cloud Computing (3 credit hours)

CS 6067 – User Interface I (3 credit hours)
This course introduces the basic concepts of human computer interaction and the latest development of the technology for developing interactive systems. Major topics cover the role of computer technology, human users and human factors for designing windows-based applications, and design methodologies for building software applications.
**CS 6068 – Parallel Computing (3 credit hours)**
This course is designed as a dual level and senior undergraduate level course introducing the theory and practice of parallel computing. The course seeks to empower students with the computational thinking and practical programming skills needed to achieve terascale and petascale computing performance in all science and engineering disciplines. Students will study and gain experiences with several parallel algorithmic design patterns. Student will study the critical system and architectural design issues associated with parallel computing. Students will gain experience with parallel programming development environments and learn programming methodologies using a chosen platform. Students will learn analytical techniques for understanding the scalability and portability of parallel computing software. The course is lab and project oriented.

**CS 7081 – Advanced Algorithms I (3 credit hours)**
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.

**CS 8021 – Pattern Recognition (3 credit hours)**
The topics covered will include Statistical Pattern Recognition - its basics and applications, algorithms for clustering and their analysis. A flavor 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.

**DB 9088 – Regulation of Gene Expression (2 credit hours)**
Provides a fundamental knowledge of how eukaryotic gene expression is regulated, with a focus on state of the art experimental approaches. This knowledge is gained through a combination of both lecture and a discussion of the primary literature with ample opportunities for student-student and student-faculty interaction. Discussion sessions focus on the primary literature, utilizing a mix of both research publications and authoritative reviews of current trends in gene regulation research. Important areas of consideration will include the following: 1. The basics of transcription and promoters 2. DNA-binding proteins and transcription factors. 3. Cis-regulatory sequences, trans-acting factors and the assembly of transcriptional complexes 4. mRNA metabolism - processing, splicing, stability 5. Non-coding RNAs in gene regulation 6. Translation 6. Chromatin structure and epigenetics in the control of gene expression 7. Genetic mechanisms of cell and tissue differentiation 8. Global approaches to understanding the architecture of the genome 9. An overview of Bioinformatic and Computational Approaches 10. A literature review of the major research questions and results.

**EECE 6042 – Digital Image Processing (3 credit hours)**
Digital image foundation and characterization, discrete transforms, image enhancement, encoding, compression and restoration. Prerequisite: senior or graduate standing.

**EECE 8075 – Data Warehousing and Mining (3 credit hours)**
Data warehouse design with conceptual data models and physical storage techniques; data mining techniques including clustering, pattern recognition, and data visualization.

**MCP 6031C – Computational Systems Biology (3 credit hours)**
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 (e.g. 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.

**STAT 6043 – Applied Bayesian Analysis (3 credit hours)**
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.