Biomedical Informatics Graduate Certificate Course Descriptions
University of Cincinnati College of Medicine

Prerequisite Courses

CS 4071 – Design & Analysis of Algorithms *(3 credit hours)*
An introduction to the study of sequential algorithms. Analysis of computing time, asymptoticnotation, introduction to lower bound theory. Induction, correctness proofs, and recurrence relations. Major design strategies: the greedy method, divide-and-conquer, dynamic programming. Graph and network algorithms.

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.

Core Courses

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.

BMIN 7003 – Biomedical Informatics Seminar *(1 credit hour)*
The student will be expected to attend a weekly seminar in the areas of medical, clinical and bio-informatics, as well as general computer science topics related to biomedical research. A mix of research talks available from College of Engineering and Applied Science, College of Medicine, and Cincinnati Children's Hospital and Medical Center can be used to satisfy the requirements of this seminar course.

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 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.

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Data Management *(select one course)*

CS 6054 – Database Theory *(3 credit hours)*
A discussion of databases, with emphasis upon theory. Formal models for database system architectures. Relational, Entity/Relationship, Object-Oriented, and Semi-structured models. Methodologies for manipulating and specifying models. Foundations of query languages.

BE/PH 8093 – Introduction to Database Management Systems *(3 credit hours)*
This course emphasizes on hands-on experience of developing and using databases. Students will learn basic concepts of database techniques, use SQL to develop relational databases (with MySQL) and use NoSQL to develop non-relational databases (with CouchDB), and develop database applications to solve practical problems in biomedical science with big data. The course is highly interactive. Students will be trained to write R code in the classroom to interact with databases and perform data analyses.

Elective Courses *(Select Two Courses)*

BE 7066 – Principles of Clinical Trials *(3 credit hours)*
A historical perspective of clinical trials. Type I, II, III, and IV trials. Protocols and Institutional Review Board approval. Study designs. Simple randomization. Block randomization. Adaptive randomization. Use of R software in implementing randomization procedures. Double-blind studies. Sample size calculations. Data analysis issues. Early termination of trials. Follow-up studies. Reporting and interpreting results of trials. Multi-center trials.

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.

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 o 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,

Elective Courses

BE 8068 – Genetics of Complex Disease *(continued)*
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.

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 Big Data, with the overarching goal of learning from data in order to gain useful predictions and insights.

CS 6033 – Artificial Intelligence *(3 credit hours)*
The course will cover in detail the topics of state space search, game tree search, constraint satisfaction, and 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.

CS 6072 – Network Science *(3 credit hours)*
1. Graph theory, degree distribution, connected components, clustering coefficient, shortest paths, diameter
2. Random graphs, the Erdos-Renyi model, giant component, phase transitions
3. The scale-free property, power laws, small-world networks, degree-preserving randomization
4. Evolving networks, preferential attachment
5. Degree correlation, assortativity, structural disassortativity
6. Network robustness, network breakdown, random failure and attacks
7. Communities, modularity and modularity-maximization algorithms, the Bron-Kerbosch clique enumeration algorithm, clique graphs and clique percolation, the Louvain algorithm, Informap
8. Spreading phenomena, epidemic modeling, network epidemics
9. Visualization algorithms

CS 6073 – Deep Learning *(3 credit hours)*
1. Deep feedforward networks: gradient-based learning, hidden units
2. Regularization for deep learning: sparse representations
3. Optimization for training deep models: adaptive learning rates
4. Convolutional networks: pooling, unsupervised features
5. Recurrent and recursive networks: long short-term memory
6. Autoencoders: semantic hashing
7. Representation learning: distributed representation, one-shot learning
8. Structured probabilistic models for deep learning: sampling
9. Deep generative models: Boltzmann machines

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.

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Elective Courses

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.

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

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.

GNTD 7001 – Principles of Molecular and Cellular Biology *(3-4 credit hours)*
Principles of Molecular and Cellular Biology is designed primarily as a 4 credit hour 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 a subset of 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. Structurally the course has been designed as a set of four consecutive self-contained 1 credit hour modules, so that some students may register for one or more of these if they so choose. These modules are entitled as follows: 1. Biomolecules; 2. Basic Genetic Mechanisms; 3. Cell Cycle & Trafficking; 4. Cell Communication & Movement.

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.