SCHOOL OF MEDICINE
CASE WESTERN RESERVE UNIVERSITY

Master's Degree in Biomedical and Health Informatics

The Biomedical and Health Informatics (BHI) program offers pragmatic, interdisciplinary areas of study immediately relevant in contemporary health systems or research enterprises. Our Master's degree program encompasses both biomedical research and clinical care informatics with applications to precision medicine, accountable care organizations, and reproducible science.

Our program provides grounding across multiple disciplines and will be of interest if you seek a career in which you:

- Analyze patient diagnoses, treatments and outcomes, based on electronic health records, to inform best practices in clinical care
- Design or manage studies in the clinical setting to inform quality and safety process improvements
- Collaborate in biomedical research, including the analysis of large genetic and various "omics" studies, integrated with clinical or population data, to advance the understanding of diseases
- Design and manage studies that draw from clinical, cohort or population data to inform the assessment and development of devices, therapeutics or other interventions

We bring together a diverse group of faculty from across Case Western Reserve University – the School of Medicine, the Weatherhead School of Business, and the School of Engineering – for a cross-disciplinary approach that offers the opportunity to craft tailored areas of study grounded in core competencies:

- Data analytics
- Biomedical, clinical and/or population health research
- Computational and systems research design

Curriculum Requirements

1. Required core courses (3 courses, 9 credits)
    - Introduction to Health Informatics (MPHP 532/HSMC432)
    - Computing in Biomedical and Health Informatics (PQHS 416)
    - Statistical Methods I (PQHS 431)

2. Required distribution of courses (3 courses, 9 credits), choose one from each core
    - Biomedical and Health (select a course from 4 courses)
    - Computation and System Design (select a course from 5 courses)
    - Data Analytics (select a course from 11 courses)

3. Elective courses (2-3 courses, 6-9 credits), choose additional electives from cores or from other approved electives (14 other courses))
    - Plan A: Concentration-specific elective courses (6 credits)

- Plan B: Concentration-specific elective courses (9 credits)

4. Required thesis (6 credits, Plan A) OR project (3 credits, Plan B)
    - Master's Thesis (PQHS 651, Plan A)
    - Master Project Research/Practicum/Internship (PHQS 603, Plan B)

Total credits - 30

Students may obtain concentration designations as part of their MS in Biomedical and Health Informatics in the following three areas is they fulfill additional distribution requirements:

- Health Informatics Management
- Clinical Informatics
- Bioinformatics

Example Curriculum Outline: MS in Biomedical and Health Informatics

Year-by-year outline of study for the MS. Plans A and B: Required courses in Bold. Electives also listed.

Semester 1	**Courses**	**Title**	Credits	Graded or P/F
	MPHP 532/HSMC 432	**Introduction to Health Informatics**	3	Graded
	PQHS 431	**Statistics I**	3	Graded
	EECS 433	Database Systems	3	Graded
		Total Credits	**9**	
Semester 2	**PQHS 416**	**Computing in Biomedical and Health Informatics**	3	Graded
	PQHS 471	Machine Learning & Data Mining	3	Graded
	PQHS 432	Statistical Methods II	3	Graded
	PQHS 501	Research Seminar	0	P/F
		Total Credits	**9**	
Semester 3	EECS 493	Software Engineering	3	Graded
	PQHS 432	Statistical Methods II	3	Graded
	Plan A: PQHS 651	Master's Thesis **(Plan A)**	3 **(A)**	P/F
	Plan B: ACCT 401H	Accounting for Healthcare **(Plan B)**	3 **(B)**	Graded
		Total Credits	**9**	
Semester 4	**Plan A:** PQHS 651	Master's Thesis **(Plan A)**	3 **(A)**	P/F
	Plan B: PQHS 601/602	Project/Internship/Practicum with written report graded (A-F) **(Plan B)**	3 **(B)**	P/F
		Total Credits	**3**	
		Total Credits for MS Program	**30**	

Academic Requirements for Master's Degree in Biomedical and Health Informatics

Plan A – MS with a thesis based on research and final oral examination
Plan B – MS requiring written internship/practicum report that is graded (A-F)

Required Core Courses: Descriptions

Total number of courses: 3
Total course credits: 9

Course Number: MPHP 532/HSMC432
Course Title: Introduction to Health informatics/ Health Informatics Core Issues
Duration: 1 semester
Credits: 3
Purpose: Introduction to biomedical and healthcare informatics, use of computational techniques in biomedical and healthcare settings, focus on clinical, biological, translational, and public health informatics. Review the use of computing technologies in biomedical and healthcare research as well as applications. Introduction to electronic health records (EHR), use of EHR systems in biomedical research, patient care, and impact of computing technology on healthcare. Explore the information requirements of healthcare and user community, current approaches to biomedical and healthcare data management.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: PQHS 416
Course Title: Computing in Biomedical and Health Informatics
Duration: 1 semester
Credits: 3
Purpose: Explore techniques in programming and mathematical foundations of data analysis in biomedical and healthcare context. The topics include algorithm design and analysis, logic and reasoning foundations, data management concepts, including survey of database management systems. Explore natural language processing techniques, information retrieval, and image informatics. Introduction to Big Data technologies, including parallel and distributed computing, cloud infrastructure, and scalable systems.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: PQHS 431
Course Title: Statistics I
Duration: 1 semester
Credits: 3
Purpose: Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MPHP 431.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Additional Required Courses: Distribution (3 courses, 9 credits), *choose one from each core*:

Biomedical and Health: Core Course Descriptions

Total number of courses from this core: One / Total course credits: Three

Course Number: **EBME 410**
Course Title: Medical Imaging Fundamentals
Duration: 1 semester
Credits: 3
Purpose: Physical principles of medical imaging. Imaging devices for x-ray, ultrasound, magnetic resonance, etc. Image quality descriptions. Patient risk. Recommended preparation: EBME 308 and EBME 310 or equivalent. Prereq: Graduate standing or Undergraduate with Junior or Senior standing and a cumulative GPA of 3.2 or above
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **MPHP 406**
Course Title: History and Philosophy of Public Health
Duration: 1 semester
Credits: 3
Purpose: The purpose of this course is to introduce students to the science and art of public health through an understanding of the history and philosophies that represent its foundation. Students will learn about the essentials of public health and applications of those precepts throughout history and in the present. The course will examine public health case histories and controversies from the past and present, in order to better understand solutions for the future. Offered as MPHP 306 and MPHP 406. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI students or instructor consent.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 440**
Course Title: Introduction to Population Health
Duration: 1 semester
Credits: 3
Purpose: Introduces graduate students to the multiple determinants of health including the social, economic and physical environment, health services, individual behavior, genetics and their interactions. It aims to provide students with the broad understanding of the research development and design for studying population health, the prevention and intervention strategies for improving population health and the disparities that exi st in morbidity, mortality, functional and quality of life. Format is primarily group discussion around current readings in the field; significant reading is required.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 451**
Course Title: A Data-Driven Introduction to Genomics and Human Health
Duration: 1 semester

Credits: 3
Purpose: This course introduces the foundational concepts of genomics and genetic epidemiology through four key principles: 1) Teaching students how to query relational databases using Structure Query Language (SQL); 2) Exposing students to the most current data used in genomics and bioinformatics research, providing a quantitative understanding of biological concepts; 3) Integrating newly learned concepts with prior ones to discover new relationships among biological concepts; and 4) providing historical context to how and why data were generated and stored in the way they were, and how this gave rise to modern concepts in genomics. Offered as PQHS 451, GENE 451, and MPHP 451. Prereq: PQHS 431, PQHS 490 or requisites not met permission.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 465**
Course Title: Design and Measurement in Population Health Sciences
Duration: 1 semester
Credits: 3
Purpose: This course focuses on common design and measurement approaches used in population health sciences research. This course covers the preliminary considerations used in selecting qualitative, quantitative and mixed methods research approaches including an understanding of different philosophical worldviews, strategies of inquiry and methods and procedures for each approach. The course also includes an introduction to survey design and related concepts of latent variables, factor analysis and reliability and validity. Students will develop an in-depth knowledge of these design and measurement approaches through readings, lectures, group discussions and written and oral project presentations. Prereq: PQHS 440, PQHS 431, PQHS 490, PQHS 432, PQHS 460, PQHS 444 and PQHS 445.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 490**
Course Title: Epidemiology: Introduction to Theory and Methods
Duration: 1 semester
Credits: 3
Purpose: This course provides an introduction to the principles of epidemiology covering the basic methods necessary for population and clinic-based research. Students will be introduced to epidemiologic study designs, measures of disease occurrence, measures of risk estimation, and casual inference (bias, confounding, and interaction) with application of these principles to specific fields of epidemiology. Classes will be a combination of lectures, discussion, and in-class exercises. It is intended for students who have a basic understanding of the principals of human disease and statistics. Offered as PQHS 490 and MPHP 490. Prereq or Coreq: PQHS 431 or requisites not met permission.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Computation and System Design: Core Course Descriptions

Total number of courses from this core: One / Total course credits: Three

Course Number: EECS 458
Course Title: Introduction to Bioinformatics
Duration: 1 semester
Credits: 3
Purpose: Fundamental algorithmic methods in computational molecular biology and bioinformatics discussed. Sequence analysis, pairwise and multiple alignment, probabilistic models, phylogenetic analysis, folding and structure prediction emphasized. Recommended preparation: EECS 340, EECS 233
Assessment of Competency: Grades

Course Number: EECS 433
Course Title: Database Systems
Duration: 1 semester
Credits: 3
Purpose: Basic issues in file processing and database management systems. Physical data organization. Relational databases. Database design. Relational Query Languages, SQL. Query languages. Query optimization. Database integrity and security. Object-oriented databases. Object-oriented Query Languages, OQL. Recommended preparation: EECS 341 and MATH 304.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: EECS 454
Course Title: Analysis of Algorithms
Duration: 1 semester
Credits: 3
Purpose: This course covers fundamental topics in algorithm design and analysis in depth. Amortized analysis, NP-completeness and reductions, dynamic programming, advanced graph algorithms, string algorithms, geometric algorithms, local search heuristics. Offered as EECS 454 and OPRE 454. Prereq: EECS 340.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: EECS 477
Course Title: Advanced Algorithms
Duration: 1 semester
Credits: 3
Purpose: Design and analysis of efficient algorithms, with emphasis on network flow, combinatorial optimization, and randomized algorithms. Linear programming: duality, complementary slackness, total unimodularity. Minimum cost flow: optimality conditions, algorithms, applications. Game theory: two-person zero-sum games, minimax theorems. Probabilistic analysis and randomized algorithms: examples and lower bounds. Approximation algorithms for NP-hard problems: examples, randomized rounding of linear programs.

EECS 477 cont'd:

Prereq: EECS 302, EECS 340, MATH 201, MATH 380
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: EECS 493
Course Title: Software Engineering
Duration: 1 semester
Credits: 3
Purpose: Introduction to software engineering; software lifecycle models; development team organization and project management; requirements analysis and specification techniques; software design techniques; programming practices; software validation techniques; software maintenance practices; software engineering ethics. Undergraduates work in teams to complete a significant software development project. Graduate students are required to complete a research project. Offered as EECS 393, EECS 393N, and EECS 493.
Counts as SAGES Senior Capstone.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: PQHS 471
Course Title: Machine Learning & Data Mining
Duration: 1 semester
Credits: 3
Purpose: Vast amount of data are being collected in medical and social research and in many industries. Such big data generate a demand for efficient and practical tools to analyze the data and to identify unknown patterns. We will cover a variety of statistical machine learning techniques (supervised learning) and data mining techniques (unsupervised learning), with data examples from biomedical and social research.
Specifically, we will cover prediction model building and model selection (shrinkage, Lasso), classification (logistic regression, discriminant analysis, k-nearest neighbors), tree-based methods (bagging, random forests, boosting), support vector machines, association rules, clustering and hierarchical clustering. Basic techniques that are applicable to many of the areas, such as cross-validation, the bootstrap, dimensionality reduction, and splines, will be explained and used repeatedly. The field is fast evolving and new topics and techniques may be included when necessary. Prereq: PQHS 431
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Data Analytics Core: Course Descriptions

Total number of courses from this core: One/ Total course credits: three

Course Number:
PQHS 432
Course Title: Statistical Methods II
Duration: 1 semester
Credits: 3
Purpose: Methods of analysis of variance, regression and analysis of quantitative data. Emphasis on computer solution of problems drawn from the biomedical sciences. Design of experiments, power of tests, and adequacy of models. Offered as BIOL 432, PQHS 432, CRSP432 and MPHP 432. Prereq: PQHS 431 or equivalent.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **EBME 419**
Course Title: Applied Probability and Stochastic Processes for Biology
Duration: 1 semester
Credits: 3
Purpose: Applications of probability and stochastic processes to biological systems. Mathematical topics will include: introduction to discrete and continuous probability spaces (including numerical generation of pseudo random samples from specified probability distributions), Markov processes in discrete and continuous time with discrete and continuous sample spaces, point processes including homogeneous and inhomogeneous Poisson processes and Markov chains on graphs, and diffusion processes including Brownian motion and the Ornstein-Uhlenbeck process. Biological topics will be determined by the interests of the students and the instructor. Likely topics include: stochastic ion channels, molecular motors and stochastic ratchets, actin and tubulin polymerization, random walk models for neural spike trains, bacterial chemotaxis, signaling and genetic regulatory networks, and stochastic predator-prey dynamics. The emphasis will be on practical simulation and analysis of stochastic phenomena in biological systems. Numerical methods will be developed using a combination of MATLAB, the R statistical package, MCell, and/or URDME, at the discretion of the instructor.
Student projects will comprise a major part of the course. Offered as BIOL 319, EECS 319, MATH 319, SYBB 319, BIOL 419, EBME 419, MATH 419, PHOL 419, and SYBB 419
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 459**
Course Title: Longitudinal Data Analysis
Duration: 1 semester
Credits: 3
Purpose: This course will cover statistical methods for the analysis of longitudinal data with an emphasis on application in biological and health research. Topics include exploratory data analysis, response feature analysis, growth curve models, mixed-effects models, generalized estimating equations, and missing data. *Prereq: PQHS 432.*
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 453**
Course Title: Categorical Data Analysis
Duration: 1 semester
Credits: 3
Purpose: Categorical data are often encountered in many disciplines including in the fields of clinical and biological sciences. Analysis methods for analyzing categorical data are different from the analysis methods for continuous data. There is a rich a collection of methods for categorical data analysis. The elegant "odds ratio" interpretation associated with categorical data is a unique one. This online course will cover cross-sectional categorical data analysis theories and methods. From this course, students will learn standard categorical data analysis methods and its applications to the biomedical and clinical studies. This particular course will focus mostly on statistical methods for categorical data analysis arising from various fields of studies including clinical studies; those who take it will come from a wide variety of disciplines. The course will include video lectures, group discussion and brainstorming, homework, simulations, and collaborative projects on real and realistic problems in human health tied directly to the student's own professional interests. Focus will be given to logistic regression methods. Topics include (but not limited to) binary response, multi-category response, count response, model selection and evaluation, exact inference, Bayesian methods for categorical data, and supervised statistical learning methods. This course stresses how the core statistical principles, computing tools, and visualization strategies are used to address complex scientific aims powerfully and efficiently, and to communicate those findings effectively to researchers who may have little or no experience in these methods. Recommended preparation: Advanced undergraduate students, and graduate students in Biostatistics or other quantitative sciences with a background in statistical methods (at least one statistics course, equivalent to the PQHS 431 course experience)
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 515**
Course Title: Secondary Analysis of Large Health Care Data Sets
Duration: 1 semester
Credits: 3
Purpose: Development of skills in working with the large-scale secondary data bases generated for research, health care administration/billing, or other purposes. Students will become familiar with the content, strength, and limitations of several data bases; with the logistics of obtaining access to data bases; the strengths and limitations of routinely collected variables; basic techniques for preparing and analyzing secondary data bases and how to apply the techniques to initiate and complete empirical analysis. *Recommended preparation: PQHS 414 or equivalent; PQHS 431 or PQHS 460 and PQHS 461 (for HSR students).*
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 458**
Course Title: Statistical Methods for Clinical Trials
Duration: 1 semester
Credits: 3
Purpose: This course will focus on special statistical methods and philosophical issues in the design and analysis of clinical trials. The emphasis will be on practically important issues that are typically not covered in standard biostatistics courses. Topics will include: randomization techniques, intent-to-treat analysis, analysis of compliance data, equivalency testing, surrogate endpoints, multiple comparisons, sequential testing, and Bayesian methods. Offered as PQHS 458 and MPHP 458. Prereq: PQHS 432 or MPHP 432.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 467**
Course Title: Comparative and Cost Effectiveness Research
Duration: 1 semester
Credits: 3
Purpose: Comparative effectiveness research is a cornerstone of healthcare reform. It holds the promise of improved health outcomes and cost containment. This course is presented in a convenient 5-day intensive format in June. There are reading assignments due prior to the 1st session. Module A, Days 1-2: Overview of comparative effectiveness research (CER) from a wide array of perspectives: individual provider, instituti on, insurer, patient, government, and society. Legal, ethical and social issues, as well as implications for population and public health, including health disparities will also be a component. Module B, Day 3: Introduction to the various methods, and their strengths, weaknesses and limitations. How to read and understand CER papers. Module C, Days 4-5: Cost-Effectiveness Analysis. This will cover costing, cost analysis, clinical decision analysis, quality of life and cost-effectiveness analysis for comparing alternative health care strategies. Trial version of TreeAge software will be used to create and analyze a simple cost- effectiveness model. The full 3-credit course is for taking all 3 modules. Modules A or C can be taken alone for 1 credit. Modules A and B or Modules B and C can be taken together for a total of 2 credits. Module B cannot be taken alone. If taking for 2 or 3 credits, some combination of term paper, project and/or exam will be due 30 days later. Offered as PQHS 467 and MPHP 467
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Electives: Choose additional electives from the above cores, or from other approved courses listed below.

Distribution: 2-3 courses for 6-9 credits, depending on if you are in Master's A or Master's B program.

Electives

Course Number: **ACCT 401H**
Course Title: Accounting for Healthcare
Duration: 1 semester
Credits: 3
Purpose: This course exposes MSM-Healthcare students to ways that accounting information helps managers monitor and improve the performance of organizations. After studying the nature and limitations of accounting information, we explore how financial, cost, tax, and regulatory accounting are used by various stakeholders.
From this effort, students become comfortable evaluating accounting recognition, valuation, classification, and disclosure issues that arise in an executive's career. Finally, we study how accounting is a feedback loop that enables managers to assess consequences of past decisions and think about what should be done going forward. Feedback loops, in turn, can give rise to observer effects and/or unpredictable outcomes. Course content contributes to achieving the program goal of strengthening a student's ability to promote positive change in healthcare.
Prereq: MSM Healthcare students only.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **BETH 417**
Course Title: Introduction to Public Health Ethics
Duration: 1 semester
Credits: 3
Purpose: The course will introduce students to theoretical and practical aspects of ethics and public health. This course will help students develop the analytical skills necessary for evaluating of ethical issues in public health policy and public health prevention, treatment, and research. Will include intensive reading and case- based discussions. Evaluation based on class participation, a written exercise and a case analysis. Open to graduate students with permission from instructors **Course Format**: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **BETH 503**
Course Title: Research Ethics and Regulation
Duration: 1 semester
Credits: 3
Purpose: This course is designed to introduce students to the ethical, policy, and legal issues raised by research involving human subjects. It is intended for law students, post-doctoral trainees in health-related disciplines and other students in relevant fields. Topics include (among others): regulation and monitoring of research; research in third-world nations; research with special populations; stem cell and genetic research; research to combat bioterrorism; scientific misconduct; conflicts of interest; commercialization and intellectual property; and the use of deception and placebos. Course will meet once per week for 2 hours throughout the semester. Grades will be given based on class participation and a series of group projects and individual short writing assignments. Offered as BETH 503, CRSP 603 and LAWS 5225
Assessment of Competency: Grades

Course Number: **BETH 422**
Course Title: Clinical Ethics: Theory & Practice
Duration: 1 semester
Credits: 3
Purpose: This course will focus on both theoretical and practical issues in clinical ethics. Clinical ethics will be distinguished from other areas of bioethics by highlighting distinctive features of the clinical context which must be taken into account in clinical ethics policy and practice. Fundamental moral and political foundations of clinical ethics will be examined, as will the role of bioethical theory and method in the clinical context. Topical issues to be considered may include informed consent; decision capacity; end of life decision making; confidentiality and privacy; the role and function of ethics committees; ethics consultation; the role of the clinical ethicist; decision making in various pediatric settings (from neonatal through adolescent); the role of personal values in professional life (e.g., rights of conscience issues, self disclosure and boundary issues); dealing with the chronically non-adherent patient; ethical issues in organ donation and transplant; health professional-patient communication; medical mistakes; and other ethical issues that emerge in clinical settings. **Assessment of Competency**: Grades

Course Number: **CRSP 401**
Course Title: Introduction to Clinical Research Summer Series
Duration: 1 semester
Credits: 3
Purpose: This course is designed to familiarize one with the language and concepts of clinical investigation and statistical computing, as well as provide opportunities for problem-solving, and practical application of the information derived from the lectures. The material is organized along the internal logic of the research process, beginning with mechanisms of choosing a research question and moving into the information needed to design the protocol, implement it, analyze the findings, and draw and disseminate the conclusion(s). Prereq: M.D., R.N., Ph.D., D.D.S., health professionals.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **EECS 494**
Course Title: Introduction to Information Theory
Duration: 1 semester
Credits: 3
Purpose: This course is intended as an introduction to information and coding theory with emphasis on the
mathematical aspects. It is suitable for advanced undergraduate and graduate students in mathematics, applied mathematics, statistics, physics, computer science and electrical engineering. Course content: Information measures-entropy, relative entropy, mutual information, and their properties. Typical sets and sequences, asymptotic equipartition property, data compression. Channel coding and capacity: channel coding theorem. Differential entropy, Gaussian channel, Shannon-Nyquist theorem. Information theory inequalities (400 level). Additional topics, which may include compressed sensing and elements of quantum information theory. Recommended Preparation: MATH 201 or MATH 307. Offered as MATH 394, EECS 394, MATH 494, and EECS 494.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **HSMC 412**
Course Title: Lean Services Operations
Duration: 1 semester
Credits: 3
Purpose: The course will be delivered over four modules: 1) Service Process Blueprints, 2) Managing Capacity in Service Systems, 3) Mapping the Value Stream (current and future state), and 4) Inventory Management in Service Systems. The topics considered are viewed in the context of healthcare management, financial services, insurance firms, call centers, back-office operations, and other applications. Through these topics, the participants will be trained in tools that help them understand customers' expectations and needs and to identify service system characteristics that can meet these needs. We will learn how to identify errors in service and troubleshoot these problems by identifying the root causes of errors. Subsequently, we will discuss how one can modify the product or service design so as to prevent defects from occurring. Finally, we will establish performance metrics that help evaluate the effectiveness of the Lean system in place. These efforts will result to improved quality. This course is not oriented toward specialists in service management. Its goal is to introduce you to the environments and help you appreciate the problems that operations managers are confronted with. Then, we will typically discuss some system specifics and emphasize the principles and issues that play key role in their management. Offered as HSMC 412 and OPMT 412.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number:
HSMC 420
Course Title: Health Finance
Duration: 1 semester
Credits: 3
Purpose: Exploration of economic, medical, financial and payment factors in the U.S. healthcare system sets the framework for the study of decisions by providers, insurers, and purchasers in this course. The mix of students from various programs and professions allows wide discussion from multiple viewpoints. Offered as BAFI 420 and HSMC 420. Prereq: ACCT 401 or ACCT 401H
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **HSMC 421**
Course Title: Health Economics and Strategy
Duration: 1 semester
Credits: 3
Purpose: This course has evolved from a theory-oriented emphasis to a course that utilizes economic principles to explore such issues as health care pricing, anti-trust enforcement and hospital mergers, choices in adoption of managed care contracts by physician groups, and the like. Instruction style and in-class group project focus on making strategic decisions. The course is directed for a general audience, not just for students and concentration in health systems management. Offered as ECON 421, HSMC 421, and MPHP 421.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **HSMC 456**
Course Title: Health Policy and Management Decisions
Duration: 1 semester
Credits: 3
Purpose: This seminar course combines broad health care policy issue analysis with study of the implications for specific management decisions in organizations. This course is intended as an applied, practical course where the policy context is made relevant to the individual manager. Offered as HSMC 456 and MPHP 456.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **IBMS 500**
Course Title: On Being a Professional Scientist: The Responsible Conduct of Research
Duration: 1 semester
Credits: 1
Purpose: The goal of this course is to provide graduate students with an opportunity to think through their professional ethical commitments before they are tested, on the basis of the scientific community's accumulated experience with the issues. Students will be brought up to date on the current state of professional policy and federal regulation in this area, and, through case studies, will discuss practical strategies for preventing and resolving ethical problems in their own work. The course is designed to meet the requirements for "instruction about responsible conduct in research" for BSTP and MSTP students supported through NIH/ ADAMHA institutional training grant programs at Case. Attendance is required.
Assessment of Competency: Grades

Course Number: **NEUR 478**
Course Title: Computational Neuroscience
Duration: 1 semester
Credits: 3
Purpose: Computer simulations and mathematical analysis of neurons and neural circuits, and the computational properties of nervous systems. Students are taught a range of models for neurons and neural circuits, and are asked to implement and explore the computational and dynamic properties of these models. The course introduces students to dynamical systems theory for the analysis of neurons and neural learning, models of brain systems, and their relationship to artificial and neural networks. Term project required.
Students enrolled in MATH 478 will make arrangements with the instructor to attend additional lectures and complete additional assignments addressing mathematical topics related to the course. Recommended preparation: MATH 223 and MATH 224 or BIOL 300 and BIOL 306. Offered as BIOL 378, COGS 378, MATH 378, BIOL 478, EBME 478, EECS 478, MATH 478 and NEUR 478.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 457**
Course Title: Current Issues in Genetic Epidemiology: Design and Analysis of Sequencing Studies.
Duration: 1 semester
Credits: 3
Purpose: Statistical methods to deal with the opportunities and challenges in Genetic Epidemiology brought about by modern sequencing technology. Some computational issues that arise in the analysis of large sequence data sets will be discussed. The course includes hands-on experience in the analysis of large sequence data sets, in a collaborative setting. Prereq: PQHS 451 and PQHS 452.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **PQHS 468**
Course Title: The Continual Improvement of Healthcare: An Interdisciplinary Course
Duration: 1 semester
Credits: 3
Purpose: This course prepares students to be members of interprofessional teams to engage in the continual improvement in health care. The focus is on working together for the benefit of patients and communities to enhance quality and safety. Offered as PQHS 468, MPHP 468, NURS 468.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **SYBB 459**
Course Title: Bioinformatics for Systems Biology
Duration: 1 semester
Credits: 3
Purpose: Description of omic data (biological sequences, gene expression, protein-protein interactions, protein-DNA interactions, protein expression, metabolomics, biological ontologies), regulatory network inference, topology of regulatory networks, computational inference of protein-protein interactions, protein interaction databases, topology of protein interaction networks, module and protein complex discovery, network alignment and mining, computational models for network evolution, network-based functional inference, metabolic pathway databases, topology of metabolic pathways, flux models for analysis of metabolic networks, network integration, inference of domain-domain interactions, signaling pathway inference from protein interaction networks, network models and algorithms for disease gene identification, identification of dysregulated subnetworks network-based disease classification. Offered as EECS 459 and SYBB 459.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Course Number: **SYBB 421/ EBME 473**
Course Title: Fundamentals of Clinical Information Systems.
Duration: 1 semester
Credits: 3
Purpose: Technology has played a significant role in the evolution of medical science and treatment. While we often think about progress in terms of the practical application of, say, imaging to the diagnosis and monitoring of disease, technology is increasingly expected to improve the organization and delivery of healthcare services, too. Information technology plays a key role in the transformation of administrative support systems (finance and administration), clinical information systems (information to support patient care), and decision support systems (managerial decision-making). This introductory graduate course provides the student with the opportunity to gain insight and situational experience with clinical information systems (CIS). Often considered synonymous with electronic medical records, the "art" of CIS more fundamentally examines the effective use of data and information technology to assist in the migration away from paper-based systems and improve organizational performance. In this course, we examine clinical information systems in the context of
(A) operational and strategic information needs, (B) information technology and analytic tools for workflow design, and (C) subsequent implementation of clinical information systems in patient care. Legal and ethical issues are explored. The student learns the process of "plan, design, implement" through hands-on applications to select CIS problems, while at the same time gaining insights and understanding of the impacts placed on patients and health care providers. Offered as EBME 473, IIME 473 and SYBB421.
Course Format: Formal classroom-based course
Assessment of Competency: Grades

Master's Thesis – A or Master's Project – B

Course Number: PQHS 651
Course Title: MS Thesis (Plan A)
Offered: Every semester
Duration: 1-2 semesters
Credits: 1-6 units per semester
Purpose: Master's thesis course
Assessment of Competency: Review with academic advisor and committee

Course Number: PQHS 603
Course Title: Master Project Research/Practicum/Internship with Graded Report (Plan B)
Offered: Every semester
Duration: 1 semester
Credits: 3
Purpose: This course is an ungraded (pass/fail) practicum/internship. Students will work with the MS in Biomedical and Health Informatics Program Director to identify potential practicum/internship mentors and opportunities. Students enrolling in this course are required to complete a minimum of 160 hours during the practicum/internship. Students are expected to record involvement in project(s) (i.e., project activities, data collection, meeting minutes) in a data/record notebook). Additionally, students are responsible for updating the MS in Biomedical and Health Informatics Program Director after completing 40, 80, 120 hours and upon completion of the Practicum/Internship. At the end of

the practicum/internship, students must complete and submit a narrative report detailing the objectives, activities performed, any deliverables, and what was learned, delivered to the preceptor and to the MS in Biomedical and Health Informatics Program Director.
Assessment of Competency: Review with academic advisor

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