# Rose-Hulman Institute of Technology Course Catalog

# Biomathematics

## MISSION STATEMENT

An increasing number of problems in the biological sciences are being solved using sophisticated mathematical and computational tools. The biomathematics degree blends mathematics, biology, and computer science in preparation for continued graduate studies and for careers in the quantitative life sciences. The degree's mission is to provide a world class undergraduate education in applied mathematics used in support of the life sciences.

The degree's mission is supported and motivated by these facts:

- Biological data is being generated with unprecedented precision and in unfathomable volumes.
- Quantifying biological observations requires mathematical and statistical analysis.
- The basic principles of complex biological systems support mathematical and computational modeling, which can lead to testable hypotheses and new discoveries.

## PROGRAM GOALS AND OBJECTIVES

The biomathematics degree will provide a broad based undergraduate experience that 1) prepares students with a rigorous education in applied mathematics, 2) educates students in the fundamental principles of biology, 3) trains students to work in a computational arena, 4) introduces students to several of the sister disciplines of computational biology, mathematical biology, bioinformatics, systems biology, and biostatistics, and 5) guides students through an advanced undergraduate research project. The degree will also liberally educate students through the study of the humanities and social sciences. Students of the program will be encouraged to participate in external and internal research programs and industrial internships and/or co-ops.
Graduates of the biomathematics program will have an ability to:

1. Mathematically model, solve, and analyze problems in biomathematics.
2. Implement computational approaches to solve and analyze problems in biomathematics.
3. Write lucidly about biomathematics.
4. Speak fluently and coherently about biomathematics.
5. Synthesize new and previous knowledge through a capstone experience.

## PROGRAM OUTCOMES

Graduates will be prepared for graduate study in any of the sister fields as well as for careers in the quantitative life sciences. Each graduate will complete a capstone research experience that will culminate in a written report and a public presentation.

***Requirements: 3 Free Electives 12 hours, 3 MA Electives 12 hours, 5 Tech Electives 20 hours, 1 Domain Elective 4 hours**

| SUMMARY OF GRADUATION REQUIREMENTS |
|---|

| | | |
|---|---|---|
| HSSA | Standard requirement, one course must be ENGL H290 | 36 hours |
| RHIT | RHIT 100 | 1 hour |
| Math Core | MA 111, 112, 113, 200, 221, 222, 332, 371 or 373, 381, and 223 or 382 | 40 hours |
| Biomath Core | BMTH 311, BMTH 312, BMTH 413, and one of BMTH 301 OR BMTH 302 | 16 hours |
| Basic Science | BIO 110, 130, 120 or 210, 220, and 230<br>CHEM 111, 113<br>PH 111, 112<br>one of CHEM 251 or PH 113 | 40 hours |
| Computer Science | CSSE 120 | 4 hours |
| Capstone Experience | BMTH 496, 497, 498 | 8 hours |
| Domain Elective | Any of the following, with no course substitutions permitted.<br>BIO 330 Evolutionary Biology 4R-0L-4C W (alternate years) Prereq. BIO 130<br>CHEM 330 Biochemistry I 4R-0L-4C F,S Prereq. CHEM 251<br>CSSE 304 Programming Language Concepts 4R-0L-4C W Prereq. CSSE 230 and CSSE 280<br>MA 366 Introduction to Real Analysis 4R-0L-4C W Prereq. MA 371 and either MA 275 or MA 276 | 4 hours |
| Math Electives | Any mathematics course numbered 300 or above, or MA 275, or MA 276 | 8 hours |
| Biomathematics Electives | Any BMTH course numbered 300 or above, or MA 482 | 4 hours |
| Technical Electives | Courses numbered 200 or above in the physical sciences, life sciences, computer science, or engineering. Coursework | 20 hours |

| | | |
|---|---|---|
| | in mathematics and biomathematics is not allowed. | |
| Free Electives | | 12 hours |
| **Total** | | **193 hours** |

## FOCUS AREAS

Students earning a major in Biomathematics are encouraged to gain depth in a particular mathematical or scientific area. By pursuing focused coursework in the following suggested areas, students will advance their preparation for graduate studies or careers in mathematical life sciences. Gaining depth through advanced electives also provides biomathematics students with an opportunity to apply knowledge gained through BMTH coursework. The following focus areas are illustrative examples to consider.

### Applied Mathematics

BE 350 Biocontrol Systems
MA 275/375 Discrete and Combinatorial Algebra I/II
MA 332 Intro. to Computational Science [required for major]
MA 330 Vector Calculus
MA 342 Computational Modelings
MA 366 Real Analysis
MA 367 Functions of a Complex Variable
MA 436 Introduction to Partial Differential Equations
MA 472 Graph Theory
MA 491 Introduction to Mathematical Modeling

### Biochemistry

BMTH 312 Bioinformatics
BMTH 310 Mathematical Biology
CHEM 251/252/253 Organic Chemistry I/II/III
CHEM 326 Bioanalytical Chemistry
CHEM 330/331 Biochemistry I/II
CHEM 430 Advanced Biochemistry

### Bioinformatics & Biostatistics

BMTH 312 Bioinformatics
MA 381 Intro. to Probability with Statistics [required for major]
MA 382 Intro. to Statistics with Probability
MA 382 Engineering Statistics II
MA 386 Statistical Programming
MA 482 Bioengineering Statistics

### Biomechanics

BE 361 Biomaterials
BE 525 Biomedical Fluid Mechanics
BE 534 Soft Tissue Mechanics
BE 539 Multiscale Biomechanics
BE 545 Orthopedic Biomechanics

### Biophysics

PH 302 Biophysics
BE 525 Biomedical Fluid Mechanics

**Cellular and Molecular Biology**

BIO 220/230 Prokaryotic/Eukaryotic Cell and Molecular Biology [required for major]
BIO 205 Cellular Physiology
BIO 411 Genetic Engineering
BIO 421 Applied Microbiology
BIO 431 Genomics and Proteomics
BMTH 310 Mathematical Biology
CHEM 455 Natural Products [offered irregularly]

**Computational Biology**

BMTH 310 Mathematical Biology
BMTH 413 Computational Biology
CSSE 220 Object Oriented Software Development
CSSE 333 Database Systems
CSSE 403 Programming Language Paradigms
CSSE 431 Artificial Intelligence
MA/CS 335 Introduction to Parallel Computing
MA 342 Computational Modeling
MA 433 Numerical Analysis
MA 435 Finite Difference Methods
MA/CS 473 Design and Analysis of Algorithms

**Ecology**

BIO 130 Evolution and Diversity
BIO 264 Introduction to Environmental Science
BIO 320 Ecology
BMTH 310 Mathematical Biology

CHEM 371 Environmental Analytical Chemistry

**Epidemiology & Pathology**

BE 310/320 Analysis of Physiological Systems I/II
BIO 410 Infection and Immunity
BIO 441 Virology
BIO 451 Cancer Biology
BIO 461 Evolutionary Medicine
BIO 471 Genetic and Molecular Analysis of Inherited Human Disease
BMTH 310 Mathematical Biology

**Evolution**

BIO 130 Evolution and Diversity
BIO 330 Evolutionary Biology
BIO 461 Evolutionary Medicine
SV 386 Human Evolution

**Imaging and Optics**

BE 435 Biomedical Optics
ECE 480 Introduction to Image Processing

BE 541 Medical Imaging Systems
MA 429 Mathematical Methods of Image Processing
PH 302 Biophysics

**Medicine**

BIO 120 Comparative Anatomy and Physiology
BIO 410 Infection and Immunity
BIO 441 Virology
BIO 451 Cancer Biology
BIO 461 Evolutionary Medicine
BIO 471 Genetic and Molecular Analysis of Inherited Human Disease
BE 541 Medical Imaging Systems
CHEM 251/252/253 Organic Chemistry I/II/III
CHEM 330/331 Biochemistry I/II

CHEM 420 Advanced Biochemistry

**Physiology**

BIO 120 Comparative Anatomy and Physiology
BIO 205 Cellular Physiology
BE 310/320 Analysis of Physiological Systems I & II
BE 520 Introduction to Brain Machine Interfaces

**SECOND MAJOR IN BIOMATHEMATICS**
The second major in biomathematics is open to all majors with the following requirements and restrictions. Eligibility and limitations

- The MA/BMTH double major must be separated by at least 24 hours.

| **REQUIREMENTS (72 HOURS)** | | |
|---|---|---|
| Math Core | MA 221. 332, 371 or 373, 381, and 223 or 382 | 20 hours |
| Biomath Core | BMTH 311, BMTH 312, BMTH 413, and one of BMTH 301 OR BMTH 302 | 16 hours |
| Math Electives | Any mathematics course numbered 300 or above, or MA275, or MA 276 | 8 hours |
| Biomathematics Electives | Any BMTH course numbered 300 or above, or MA482 | 4 hours |
| Biology | BIO 110 and three courses from different categories described below<br>BIO 130<br>BIO 120 or 210<br>BIO 205 or 230 | 16 hours |

| | | |
|---|---|---|
| | BIO 220 | |
| Senior Capstone Experience | BMTH 496, 497, 498 | 8 hours |

**MINOR IN BIOMATHEMATICS**

Any student not pursuing a major or second major in biomathematics may obtain a minor in biomathematics by taking the following courses:

| **REQUIREMENTS (47 HOURS)** | | |
|---|---|---|
| Math Core | MA 111, 112, 113, 221, 222, and 223 or 382 | 27 hours |
| Biomath Core | any three BMTH courses numbered 300 or above | 12 hours |
| Biology | BIO 110 and one of BIO 205, 210, 220, 230 | 8 hours |

**Approval and Biomathematics Minor Form**
All minors must be approved by the biomathematics minor advisor and the student's advisor. The department has a form for the planning and approval of a biomathematics minor.

**Notes and Limitations on Requirements:**

- Almost all students are required to take six foundational courses as a requirement for their major; therefore only five "extra courses" are required for most students.
- Only MA 111, MA 112, MA 113, MA 221, MA 222 and one of MA 223, MA 381, or MA 382 can be counted towards any combination of the multiple minors offered by the mathematics department.
- Biomathematics courses cannot be used to count toward both Free Mathematics Electives for a mathematics major and also towards a biomathematics minor.

# Plan of Study

## Freshman

### Fall

| Course | Credit |
|---|---|
| BIO 130 Evolution and Diversity | 4 |
| CHEM 111 General Chemistry | 4 |
| MA 111 Calculus I | 5 |
| HUM H190 First-Year Writing Seminar | 4 |
| RHIT 100 Foundations for Rose-Hulman Success | 1 |
| | **Total Credits: 18** |

### Winter

| Course | Credit |
|---|---|
| PH 111 Physics I | 4 |
| CHEM 113 General Chemistry II | 4 |
| MA 112 Calculus II | 5 |
| BIO 110 Cell Structure and Function | 4 |
| | **Total Credits: 17** |

**Spring**

| Course | Credit |
|---|---|
| CSSE 120 Intro to Software Development | 4 |
| PH 112 Physics II | 4 |
| MA 113 Calculus III | 5 |
| HSSA | 4 |
| | **Total Credits: 17** |

## Sophomore

**Fall**

| Course | Credit |
|---|---|
| BIO 210 Mendelian & Molecular Genetics | 4 |
| MA 221 Matrix Algebra & Differential Equations I | 4 |
| HSSA | 4 |
| PH 113 or CHEM 251 Add'l Science | 4 |
| | **Total Credits: 16** |

**Winter**

| Course | Credit |
|---|---|
| BIO 220 Microbiology | 4 |
| MA 222 Matrix Algebra & Differential Equations II | 4 |
| MA 381 Intro. to Probability | 4 |
| HSSA | 4 |
| MA 200 Career Preparation | 1 |
| | **Total Credits: 17** |

**Spring**

| Course | Credit |
|---|---|
| BIO 230 Cell Biology | 4 |
| MA 371 Linear Algebra | 4 |

| | |
|---|---|
| HSSA | 4 |
| BMTH 301 Intro to Biomath: Continuous Models | 4 |
| | **Total Credits: 16** |

## Junior

### Fall

| Course | Credit |
|---|---|
| BMTH 311 Systems Biology | 4 |
| MA 382 Intro. to Statistics w/Prob | 4 |
| HSSA | 4 |
| Elective* | 4 |
| | **Total Credits: 16** |

### Winter

| Course | Credit |
|---|---|
| BMTH 312 Bioinformatics | 4 |
| MA 332 Intro to Computational Sci. | 4 |
| ENGL H290 Technical & Profess. Comm. | 4 |
| Elective* | 4 |
| | **Total Credits: 16** |

### Spring

| Course | Credit |
|---|---|
| BMTH Elective | 4 |
| HSSA | 4 |
| Elective* | 4 |
| Elective* | 4 |
| | **Total Credits: 16** |

## Senior

### Fall

| Course | Credit |
|---|---|
| BMTH 496 Capstone Experience I | 2 |
| HSSA | 4 |
| Elective* | 4 |
| Elective* | 4 |
| | **Total Credits: 14** |

**Winter**

| Course | Credit |
|---|---|
| BMTH 497 Capstone Experience II | 4 |
| BMTH 413 Computational Biology | 4 |
| Elective* | 4 |
| Elective* | 4 |
| | **Total Credits: 16** |

**Spring**

| Course | Credit |
|---|---|
| BMTH 498 Capstone Experience III | 2 |
| Elective* | 4 |
| Elective* | 4 |
| Elective* | 4 |
| | **Total Credits: 14** |

**NOTES**

| *Requirements: | |
|---|---|
| 3 Free Electives | 12 hours |
| 2 MA Electives | 8 hours |
| 5 Tech Electives | 20 hours |
| 1 Domain Elective | 4 hours |

# Biomathematics - Course Descriptions

**BMTH 199 Professional Experience 1R-0L-1C**
**Prerequisites:** There are no prerequisites for this course.
**Corequisites:** There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

**BMTH 295 Research Seminar in Biomathematics 1R-0L-1C Arranged**
**Prerequisites:** Consent of instructor
**Corequisites:** There are no corequisites for this course.
A seminar-style course that introduces novel problems in biomathematics. Problems will be drawn from the modern literature in biomathematics, computational biology, bioinformatics, systems biology, and biostatistics. This course may be taken at most twice for credit.

**BMTH 301 Introduction to Biomathematics: Continuous Models 4R-0L-4C (even years) S**
**Prerequisites:** MA 222 F,W,S

**Corequisites:** There are no corequisites for this course.
This course requires no previous knowledge of biology. The application of differential equations and probability to modeling and analyzing dynamic biological systems. Mathematical topics include ordinary and partial differential equations, dynamical systems, bifurcations, limit cycles, chaos, and probabilistic and stochastic modeling. Biological applications may include biochemistry, cell biology, epidemiology, neuroscience, ecology, biofluids, biomaterials, diffusion, and pattern formation.

**BMTH 302 Introduction to Biomathematics: Discrete Models 4R-0L-4C (odd years) S**
**Prerequisites:** MA 113 F,W,S
**Corequisites:** There are no corequisites for this course.
This course requires no previous knowledge of biology. The application of discrete mathematics and computational algebra for modelling biological phenomena. Topics may include: gene regulatory networks, genomics, RNA folding, neuronal networks, infectious disease modeling, phylogenetics, and/or ecological networks. Students will also use software currently used in mathematical biology research for visualization, simulation, and analysis.

**BMTH 311 Systems Biology 4R-0L-4C F (even years)**
**Prerequisites:** MA 222 F,W,S
**Corequisites:** There are no corequisites for this course.
The study of how to combine detailed biological information to build models of entire systems. Nearly any biological scale can be considered. For example, at the biochemistry level the course will consider topics such as gene regulatory networks, protein interaction networks, and metabolisms. Moving toward larger scales, systems biology can be used to study the growth of cancerous tumors, and on an even larger scale, the mating and social structure of populations. The course's focus is on how to use relational information to perform model based inquiries of an entire system.

**BMTH 312 Bioinformatics 4R-0L-4C W (even years)**
**Prerequisites:** CSSE 120 F,W,S, and MA 381 F,W,S
**Corequisites:** There are no corequisites for this course.
This course will study how to combine mathematical, statistical, probabilistic, and computational methods to analyze biological data. Example topics are sequence alignment, locating genes, structural alignment, microarray analysis, and drug design. The course emphasizes how to search and compare biological datasets to make scientific inferences.

**BMTH 413 Computational Biology 4R-0L-4C W (odd years)**
**Prerequisites:** MA 332 F,W, and either BMTH 301 S or BMTH 302 S or BMTH 311 F (even years) or BMTH 312 W (even years)
**Corequisites:** There are no corequisites for this course.
The study of how to build and validate computational models to conduct biological studies. Ex-emplary topics include molecular dynamics, haplotyping, phylogenetics, neuroscience, and population dynamics. The course will consider the implementation and analysis of algorithms that are specifically germane to the life sciences.

**BMTH 490 Topics in Biomathematics Variable Credit**
**Prerequisites:** There are no prerequisites for this course.
**Corequisites:** There are no corequisites for this course.

Varies

### BMTH 496 Capstone Experience I 2C F

**Prerequisites:** Senior standing or permission of instructor.
**Corequisites:** There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

### BMTH 497 Capstone Experience II 4C W

**Prerequisites:** BMTH 496 F
**Corequisites:** There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

### BMTH 498 Capstone Experience III 2C S

**Prerequisites:** BMTH 497 W
**Corequisites:** There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

Last updated: 09/22/2023

**Rose-Hulman**
**Institute of Technology**
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511