

MATHEMATICS

Department Website: Mathematics (<https://www.gonzaga.edu/college-of-arts-sciences/departments/mathematics/>)

The Department of Mathematics provides training in mathematics and statistics and their applications to solve problems in business, engineering, the social sciences, and other disciplines. The curriculum offers a blend of pure mathematics, applied mathematics and statistics. The department provides students with opportunities to foster their passion for mathematics and statistics, and to enhance their understanding of the role of mathematics and statistics in the world. Such opportunities include participating in conferences, community teaching, undergraduate research, and clubs. Majors are well prepared for positions in industry, government, and education, as well as for graduate studies.

All majors must take a senior comprehensive course (MATH 496 Comprehensive for Applied Mathematics or MATH 499 Comprehensive for Mathematics) in the fall semester of their final year. It is recommended that all Mathematics majors take PHYS 121 Physics I, CHEM 101 General Chemistry I, or BIOL 105 Information Flow in Biological Systems to satisfy their University Core Scientific Inquiry requirement. Prospective teachers of mathematics should consult the School of Education for the current state certification requirements.

The department involves students with activities sponsored by the Mathematical Association of America (MAA) and the Society of Industrial and Applied Mathematics (SIAM). Students may also participate in the William Lowell Putnam Mathematical Competition or the Mathematical Contest in Modeling.

Students pursuing a major in Mathematics may pursue a concentration in Statistics (or no concentration). Students pursuing a major in Applied Mathematics may choose a single concentration from the list below (or no concentration). Some Applied Mathematics concentrations may also be combined with a concentration in Statistics for a double concentration (see the list below). Other combinations of concentrations are not allowed. Students pursuing a major in Mathematics or Applied Mathematics cannot pursue a minor in Mathematics, Applied Mathematics or Statistics. Students are able to major or minor in Mathematics or Applied Mathematics, but not both.

Mathematics (BS) Major Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
MATH 259	Calculus and Analytic Geometry III	4
Upper Division		
MATH 301	Fundamentals of Mathematics	3
MATH 339	Linear Algebra	3
MATH 413	Real Analysis I	3
MATH 437	Abstract Algebra I	3
Select one of the following:		3
MATH 414	Real Analysis II	
MATH 417	Complex Variables	

MATH 438	Abstract Algebra II	
MATH 457	Number Theory and Cryptography	
MATH 459	Topology	
MATH 300-400-level electives ¹		6
MATH 400-level electives		6
MATH 499	Comprehensive for Mathematics	1
Total Hours		40

¹ One of these courses may be replaced by MATH 260 Ordinary Differential Equation.

Math Electives: cannot double-count with a required course. Cannot use MATH 335 Applied Linear Algebra, MATH 432 CIS: or MATH 496 Comprehensive for Applied Mathematics as MATH electives. Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Optional Concentration in Statistics: Statistics Concentration

Students complete the B.S. Major in Mathematics as listed above, with the following differences for Math Electives:

- Three credits instead of six for MATH 300-400 level electives,
- Three credits instead of six for MATH 400-level electives
- Plus additional statistics courses.

Code	Title	Hours
MATH 321	Statistics for Experimentalist	3
or MATH 422	Mathematical Statistics	
MATH 421	Probability Theory	3
MATH 425	Applied Statistical Models	3
or MATH 426	Experimental Design	
MATH 300-400-level elective ¹		3
MATH 400-level elective		3
Select two of the following Statistics Electives. One course must be MATH. Cannot double-count with courses used elsewhere.		6
MATH 422	Mathematical Statistics	
MATH 423	Stochastic Processes	
MATH 426	Experimental Design	
ECON 355	Regression Analysis	
ECON 451	Econometrics	
ECON 452	Time Series Analysis	
CPSC 322	Data Science Algorithms	
CPSC 323	Machine Learning and Intelligent Systems	
PHYS 323	Statistical Mechanics	
PSYC 450	Advanced Statistics in Psychology	
Or any course with significant probability or statistics content with approval of the Math Department Chair. All of these courses have pre-requisites and may require courses outside of the concentration to be taken.		
Total Hours		21

¹ One of these courses may be replaced by MATH 260 Ordinary Differential Equation

Math Electives: cannot double-count with a required course. Cannot use MATH 335 Applied Linear Algebra, MATH 432 CIS: or MATH 496 Comprehensive for Applied Mathematics as MATH electives. Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Mathematics (BA) Major Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
MATH 259	Calculus and Analytic Geometry III	4
Upper Division		
MATH 301	Fundamentals of Mathematics	3
MATH 339	Linear Algebra	3
MATH 413	Real Analysis I	3
or MATH 437	Abstract Algebra I	
MATH 300-400-level electives ¹		6
MATH 400-level elective		3
MATH 499	Comprehensive for Mathematics	1
Total Hours		31

¹ One of these courses may be replaced by MATH 260 Ordinary Differential Equation.

Math Electives: cannot double-count with a required course. Cannot use MATH 335 Applied Linear Algebra, MATH 432 CIS: or MATH 496 Comprehensive for Applied Mathematics as MATH electives. Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Optional Concentration in Statistics: Statistics Concentration

Students complete the B.A. Major in Mathematics as listed above, plus additional credits of statistics courses. Math electives are changed as follows:

- Three credits instead of six for MATH 300-400 level electives
- MATH 421 Probability Theory instead of a MATH 400-level elective
- Plus additional statistics courses.

Code	Title	Hours
MATH 300-400 level elective		3
MATH 421	Probability Theory	3
MATH 321	Statistics for Experimentalist	3
or MATH 422	Mathematical Statistics	
MATH 425	Applied Statistical Models	3

or MATH 426	Experimental Design	
Select two of the following Statistics Electives. One course must be MATH. Cannot double-count with courses used elsewhere.		6
MATH 422	Mathematical Statistics	
MATH 423	Stochastic Processes	
MATH 426	Experimental Design	
ECON 355	Regression Analysis	
ECON 451	Econometrics	
ECON 452	Time Series Analysis	
CPSC 322	Data Science Algorithms	
CPSC 323	Machine Learning and Intelligent Systems	
PHYS 323	Statistical Mechanics	
PSYC 450	Advanced Statistics in Psychology	
Or any course with significant probability or statistics content with approval of the Math Department Chair. All of these courses have pre-requisites and may require courses outside of the concentration to be taken.		
Total Hours		18

¹ One of these courses may be replaced by MATH 260 Ordinary Differential Equation

Math Electives: cannot double-count with a required course. Cannot use MATH 335 Applied Linear Algebra, MATH 432 CIS: or MATH 496 Comprehensive for Applied Mathematics as MATH electives. Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Applied Mathematics (BS) Major Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
MATH 259	Calculus and Analytic Geometry III	4
MATH 260	Ordinary Differential Equation ¹	3
CPSC 121	Computer Science I	3
Upper Division		
MATH 301	Fundamentals of Mathematics	3
MATH 335	Applied Linear Algebra	3
or MATH 339	Linear Algebra	
MATH 350	Numerical Methods ²	3
MATH 413	Real Analysis I ³	3
Select one of the following:		3
MATH 321	Statistics for Experimentalist ⁴	
MATH 422	Mathematical Statistics ⁵	
MATH 496	Comprehensive for Applied Mathematics	1
Select an Applied Math concentration option ⁶		23-43
Total Hours		57-77

¹ Computer Science concentration only: MATH 260 Ordinary Differential Equation optional, may be counted as a MATH 300-400 level elective.

- ² Actuarial Science Concentration students take MATH 423 Stochastic Processes instead of MATH 350 Numerical Methods.
- ³ Computer Science concentration students may choose MATH 437 Abstract Algebra I, or MATH 457 Number Theory and Cryptography instead of MATH 413 Real Analysis I.
- ⁴ Actuarial Science concentration students must take MATH 422 Mathematical Statistics (not MATH 321 Statistics for Experimentalist).
- ⁵ All non-double concentrations except Actuarial Science: If MATH 422 Mathematical Statistics is chosen, then one MATH 400-level elective may be replaced by a MATH 300-level elective.
- ⁶ Due to the interdisciplinary nature of the following options, students should make note of prerequisites and minimum grade requirements that may not be listed as degree.

The Applied Mathematics (BS) Major allows you to choose a single or double concentrations (outlined below) in addition to the major requirements.

Single Concentration options: Actuarial Science, Biology, Biochemistry, Chemistry, Computer Science, Economics, Environmental Science, Physics, Statistics

Double Concentration options: Biology and Statistics, Biochemistry and Statistics, Chemistry and Statistics, Economics and Statistics, Environmental Science and Statistics, Physics and Statistics.

No Concentration

34 credits + 23-24 credits

57-58 credits

Code	Title	Hours
Select two of the following:		8
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	
PHYS 121	Physics I	
Select one of the following:		3-4
BIOL 106	Energy Flow in Biological Systems (Select one of the following:)	
CHEM 205	Inorganic Chemistry	
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	
PHYS 122	Physics II	
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		3
MATH 400-level electives		6
Total Hours		23-24

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.

- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Optional Single Concentration:

Actuarial Science Concentration

34 credits + 35 credits

69 credits

Code	Title	Hours
ACCT 263	Accounting Analysis	3
ECON 201	Microeconomics	3
ECON 202	Macroeconomics	3
ECON 301	Intermediate Microeconomics	3
ECON 352	Money and Banking	3
ECON 352L	Money and Banking Math Lab	1
ECON 355	Regression Analysis	3
ECON 451	Econometrics	3
MATH 421	Probability Theory	3
MATH 494	Topics in Actuarial Science	1
MATH 300-400 electives		6
Select one of the following:		3
MATH 400-level elective		
ECON 452	Time Series Analysis	
Total Hours		35

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Biology Concentration

34 credits + 34 credits

68 credits

Code	Title	Hours
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	4
BIOL 106	Energy Flow in Biological Systems	3
Select two of the following:		8
BIOL 205 & 205L	Physiology and Biodiversity and Physiology and Biodiversity Lab	
BIOL 206 & 206L	Ecology and Ecology Lab	
BIOL 207 & 207L	Genetics and Genetics Lab	
BIOL 300-400 level electives		6
Select one of the following:		3

MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 400-level electives		6
Total Hours		34

Biology elective options:

Code	Title	Hours
BIOL 303	Population Ecology	3
BIOL 313	Animal Behavior	3
BIOL 323	Conservation Biology	3
BIOL 331	Parasitology	3
BIOL 333	Community Ecology	3
BIOL 335	Advanced Genetics:	3
BIOL 340	Field Botany	3
BIOL 341	Human Physiology	3
BIOL 343	Plant Community Ecology	3
BIOL 344	Introduction to GIS in Biology	3
BIOL 357	Principles of Wildlife Management	3
BIOL 360	Plant Biology	3
BIOL 367	Entomology	3
BIOL 371	Vertebrate Biology and Anatomy	3
BIOL 399	Advanced Topic:	2
BIOL 403	Marine Biology	3
BIOL 420	Physiological Ecology	3
BIOL 441	Advanced Physiology	3

Other courses may be considered on a case-by-case basis). BIOL 334 Advanced Evolution, BIOL 337 Developmental Biology, and BIOL 451 Comparative Endocrinology are allowed but require BIOL 205 Physiology and Biodiversity, BIOL 206 Ecology, and BIOL 207 Genetics as prerequisites. Up to 2 credits may come from labs associated with any of these courses.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Biochemistry Concentration

34 credits + 32 credits

67credits

Code	Title	Hours
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 231 & 231L	Organic Chemistry II and Organic Chemistry Lab II	4

CHEM 245 & 245L	Biochemistry and Biochemistry Lab	4
CHEM 399	Advanced Topics:	2
CHEM 407	Special Topics in Biochemistry	2
Select one of the following:		3

MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		3
MATH 400-level electives		6
Total Hours		32

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Chemistry Concentration

34 credits + 33 credits

67 credits

Code	Title	Hours
PHYS 121	Physics I	4
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
CHEM 205	Inorganic Chemistry	3
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 310 & 310L	Analytical Chemistry and Analytical Chemistry Lab	5
CHEM 355	Physical Chemistry	3
Select one of the following:		3

MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 400-level electives		6
Total Hours		32

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Computer Science Concentration

31 credits + 33 credits

64 credits

Code	Title	Hours
CPSC 122	Computer Science II	3
or CPSC 222	Introduction to Data Science	
Select one of the following:		3
CPSC 322	Data Science Algorithms	
CPSC 351	Theory of Computation	
CPSC 353	Applied Cryptography	
CPSC 450	Design and Analysis of Computer Algorithms	
CPSC 200-300-400 level electives		3
CPSC 300-400 level electives		3
MATH 351	Combinatorics and Graph Theory	3
Select three of the following:		9
MATH 328	Operations Research	
MATH 421	Probability Theory	
MATH 423	Stochastic Processes	
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 455	Chaos and Discrete Dynamical Systems	
MATH 300-400 elective		3
MATH 400-level electives		6
Total Hours		33

CPSC elective options:

Code	Title	Hours
CPSC 224	Software Development	3
CPSC 321	Database Management Systems	3
CPSC 322	Data Science Algorithms ¹	3
CPSC 323	Machine Learning and Intelligent Systems ¹	3
CPSC 325	Data Science Project Lab	3
CPSC 326	Organization of Program Languages	3
CPSC 331	UI/UX Design	3
CPSC 328	Computer Networks	3
CPSC 332	Web Development	3
CPSC 333	Mobile App Development	3
CPSC 334	Linux and DevOps	3
CPSC 351	Theory of Computation ¹	3
CPSC 353	Applied Cryptography ¹	3
CPSC 475	Speech and Natural Language Processing	3

Other options are CPSC 223 Algorithm and Abstract Data Structures, CPSC 425 Computer Graphics, CPSC 450 Design and Analysis of Computer Algorithms¹ (check for prerequisites).

¹ Recommended elective choices

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be

taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Economics Concentration

(34 credits + 30-31 credits)

64-65 credits

Code	Title	Hours
ECON 201	Microeconomics	3
ECON 202	Macroeconomics	3
ECON 301	Intermediate Microeconomics ¹	3
or ECON 351	Managerial Economics	
ECON 303	Game Theory and Economic Applications	3
ECON 300-400 level elective		3-4
MATH 421	Probability Theory	3
Select two of the following:		6
MATH 423	Stochastic Processes	
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 300-400 level elective		3
MATH 400-level elective		3
Total Hours		30-31

¹ ECON 301 Intermediate Microeconomics prerequisite ECON 201 Microeconomics requires a minimum grade of B-.

ECON Elective options:

Code	Title	Hours
ECON 320	Economics of Sports	3
ECON 321	International Economics ¹	3
ECON 322	Work, Wages, and Inequality	3
ECON 324	Economics of Environmental Protection	3
ECON 325	Public Finance	3
ECON 330	Antitrust Policy and Regulation	3
ECON 333	Health Economics	3
ECON 334	Behavioral Economics	3
ECON 352	Money and Banking	4
& 352L	and Money and Banking Math Lab ¹	
ECON 355	Regression Analysis	3
ECON 451	Econometrics ¹	3
ECON 452	Time Series Analysis ¹	3

¹ Recommended elective choices

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be

taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Environmental Science Concentration

34 credits + 34 credits
68 credits

Code	Title	Hours
ENVS 101	Introduction to Environmental Studies	3
ENVS 103 & 103L	Environmental Biology and Environmental Biology Lab ¹	4
Select one of the following:		4
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	
Select one of the following:		4
ENVS 110 & 110L	Earth Science and Earth Science Lab	
ENVS 202 & 202L	Applied Environmental Chemistry and Applied Environmental Chemistry Lab ²	
ENVS 320	Econ of Environmental Protectn ³	3
ENVS 384	Introduction to GIS in Biology ⁴	3
Select two of the following:		6
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		3
MATH 400-level elective		3
Total Hours		33

¹ Alternative: BIOL 206 Ecology/BIOL 206L Ecology Lab (cross-listed, prerequisite BIOL 105 Information Flow in Biological Systems/BIOL 106 Energy Flow in Biological Systems) with a C- or better.

² Prerequisite CHEM 101 General Chemistry I/CHEM 101L General Chemistry I Lab.

³ Alternative: ECON 324 Economics of Environmental Protection (prerequisite ECON 200 Economic Analysis or ECON 201 Microeconomics).

⁴ Alternative: BIOL 344 Introduction to GIS in Biology (cross-listed, prerequisite BIOL 106 Energy Flow in Biological Systems/BIOL 206 Ecology).

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Physics Concentration

34 credits + 31 credits

65 credits

Code	Title	Hours
PHYS 121 & 121L	Physics I and Physics I Lab	5
PHYS 122 & 122L	Physics II and Physics II Lab	5
PHYS 200, 300, 400 level electives		6
Select two of the following:		6
MATH 417	Complex Variables	
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		3
MATH 400-level electives		6
Total Hours		31

PHYS elective options:

Code	Title	Hours
PHYS 224	Modern Physics	3
PHYS 321	Classical Mechanics	3
PHYS 322	Electricity and Magnetism	3
PHYS 323	Statistical Mechanics	3
PHYS 324	Quantum Mechanics ¹	3
PHYS 424	Advanced Quantum Mechanics	3
PHYS 451	Fields, Oscs, and Relativity	3
PHYS 452	Optics	3
PHYS 454	Nuclear and Particle Physics ¹	3
PHYS 455	Cosmology and Astrophysics	3
PHYS 456	Biophysical Systems and Modeling	3

¹ Require PHYS 224 Modern Physics, PHYS 321 Classical Mechanics, and PHYS 322 Electricity and Magnetism as prerequisites; PHYS 424 Advanced Quantum Mechanics requires PHYS 324 Quantum Mechanics as prerequisite

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Statistics Concentration

34 credits + 31-32 credits
65-66 credits

Code	Title	Hours
Select one of the following three sets of courses:		7-8
Biology Set:		
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	

BIOL 106	Energy Flow in Biological Systems	
Physics Set:		
PHYS 121	Physics I	
PHYS 122	Physics II	
Chemistry Set:		
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	
CHEM 205	Inorganic Chemistry	
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 421	Probability Theory	3
MATH 425	Applied Statistical Models	3
or MATH 426	Experimental Design	
MATH 300-400 level elective		3
MATH 400-level electives		6
Select two courses from the Statistics Electives List ¹		6
Total Hours		31-32

¹ One course must be MATH. Cannot double-count with courses used elsewhere.

Statistics Electives List

Code	Title	Hours
MATH 422	Mathematical Statistics	3
MATH 423	Stochastic Processes	3
MATH 426	Experimental Design	3
ECON 355	Regression Analysis	3
ECON 451	Econometrics	3
ECON 452	Time Series Analysis	3
CPSC 322	Data Science Algorithms	3
CPSC 323	Machine Learning and Intelligent Systems	3
PHYS 323	Statistical Mechanics	3
PSYC 450	Advanced Statistics in Psychology	3

Or any course with significant probability or statistics content with approval of the Math Department Chair. All of these courses have pre-requisites and may require courses outside of the concentration to be taken.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Optional Double Concentrations:

Biology and Statistics Concentration

34 credits + 41 credits

75 credits

Code	Title	Hours
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	4
BIOL 106	Energy Flow in Biological Systems	3
Select two of the following:		8
BIOL 205 & 205L	Physiology and Biodiversity and Physiology and Biodiversity Lab	
BIOL 206 & 206L	Ecology and Ecology Lab	
BIOL 207 & 207L	Genetics and Genetics Lab	
BIOL 300-400 level electives		6
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 421	Probability Theory	3
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 400-level electives		3
Statistics Electives ¹		6
Total Hours		43

¹ One course must be MATH. Cannot double-count with courses used elsewhere.

Biology elective options:

Code	Title	Hours
BIOL 303	Population Ecology	3
BIOL 313	Animal Behavior	3
BIOL 323	Conservation Biology	3
BIOL 331	Parasitology	3
BIOL 333	Community Ecology	3
BIOL 335	Advanced Genetics:	3
BIOL 340	Field Botany	3
BIOL 341	Human Physiology	3
BIOL 343	Plant Community Ecology	3
BIOL 344	Introduction to GIS in Biology	3
BIOL 357	Principles of Wildlife Management	3
BIOL 360	Plant Biology	3
BIOL 367	Entomology	3
BIOL 371	Vertebrate Biology and Anatomy	3
BIOL 399	Advanced Topic:	2
BIOL 403	Marine Biology	3
BIOL 420	Physiological Ecology	3
BIOL 441	Advanced Physiology	3

Other courses may be considered on a case-by-case basis). BIOL 334 Advanced Evolution, BIOL 337 Developmental Biology, and BIOL 451

Comparative Endocrinology are allowed but require BIOL 205 Physiology and Biodiversity, BIOL 206 Ecology, and BIOL 207 Genetics as prerequisites. Up to 2 credits may come from labs associated with any of these courses.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Biochemistry and Statistics Concentration

34 credits + 41 credits
75 credits

Code	Title	Hours
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 231 & 231L	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 245 & 245L	Biochemistry and Biochemistry Lab	4
CHEM 399	Advanced Topics:	2
CHEM 407	Special Topics in Biochemistry	2
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 421	Probability Theory	3
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 300-400 level elective		3
MATH 400-level electives		3
Statistics Electives ¹		6
Total Hours		41

¹ One course must be MATH. Cannot double-count with courses used elsewhere.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Chemistry and Statistics Concentration

34 credits + 41 credits
75 credits

Code	Title	Hours
PHYS 121	Physics I	4
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	4
CHEM 205	Inorganic Chemistry	3
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 310 & 310L	Analytical Chemistry and Analytical Chemistry Lab	5
CHEM 355	Physical Chemistry	3
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 421	Probability Theory	3
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 300-400-level electives		3
Statistics Electives ¹		6
Total Hours		41

¹ One course must be MATH. Cannot double-count with courses used elsewhere.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Economics and Statistics Concentration

(34 credits + 39-40 credits)
73-74 credits

Code	Title	Hours
ECON 201	Microeconomics	3
ECON 202	Macroeconomics	3
ECON 301	Intermediate Microeconomics ¹	3
or ECON 351	Managerial Economics	
ECON 303	Game Theory and Economic Applications	3
ECON 300-400 level elective		3-4
MATH 421	Probability Theory	3
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
Select one of the following:		3

MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 300-400 level elective		3
MATH 400-level elective		3
Statistics Electives ²		9
Total Hours		39-40

¹ ECON 301 Intermediate Microeconomics prerequisite ECON 201 Microeconomics requires a minimum grade of B-.

² Two courses must be MATH. Cannot double-count with courses used elsewhere.

ECON Elective options:

Code	Title	Hours
ECON 320	Economics of Sports	3
ECON 321	International Economics ¹	3
ECON 322	Work, Wages, and Inequality	3
ECON 324	Economics of Environmental Protection	3
ECON 325	Public Finance	3
ECON 330	Antitrust Policy and Regulation	3
ECON 333	Health Economics	3
ECON 334	Behavioral Economics	3
ECON 352 & 352L	Money and Banking and Money and Banking Math Lab ¹	4
ECON 355	Regression Analysis	3
ECON 451	Econometrics ¹	3
ECON 452	Time Series Analysis ¹	3

¹ Recommended elective choices

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Environmental Science and Statistics Concentration

34 credits + 43 credits

77 credits

Code	Title	Hours
ENVS 101	Introduction to Environmental Studies	3
ENVS 103 & 103L	Environmental Biology and Environmental Biology Lab ¹	4
Select one of the following:		4
BIOL 105 & 105L	Information Flow in Biological Systems and Information Flow in Biological Systems Lab	
CHEM 101 & 101L	General Chemistry I and General Chemistry I Lab	
Select one of the following:		4

ENVS 110 & 110L	Earth Science and Earth Science Lab	
ENVS 202 & 202L	Applied Environmental Chemistry and Applied Environmental Chemistry Lab ²	
ENVS 320	Econ of Environmental Protectn ³	3
ENVS 384	Introduction to GIS in Biology ⁴	3
MATH 421	Probability Theory	3
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		3
Statistics Electives ⁵		9
Total Hours		42

¹ Alternative: BIOL 206 Ecology/BIOL 206L Ecology Lab (cross-listed, prerequisite BIOL 105 Information Flow in Biological Systems/BIOL 106 Energy Flow in Biological Systems) with a C- or better.

² Prerequisite CHEM 101 General Chemistry I/CHEM 101L General Chemistry I Lab.

³ Alternative: ECON 324 Economics of Environmental Protection (prerequisite ECON 200 Economic Analysis or ECON 201 Microeconomics).

⁴ Alternative: BIOL 344 Introduction to GIS in Biology (cross-listed, prerequisite BIOL 106 Energy Flow in Biological Systems/BIOL 206 Ecology).

⁵ Two courses must be MATH. Cannot double-count with courses used elsewhere.

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Physics and Statistics Concentration

34 credits + 40 credits

74 credits

Code	Title	Hours
PHYS 121 & 121L	Physics I and Physics I Lab	5
PHYS 122 & 122L	Physics II and Physics II Lab	5
PHYS 200, 300, 400 level electives		6
Select two of the following:		6
MATH 417	Complex Variables	
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	

MATH 462	Nonlinear Systems and Chaos	
Select one of the following:		3
MATH 425	Applied Statistical Models	
MATH 426	Experimental Design	
MATH 300-400 level elective		3
MATH 400-level electives		3
Statistics Electives ¹		6
Total Hours		37

¹ At least one course must be MATH. Cannot double-count with courses used elsewhere.

PHYS elective options:

Code	Title	Hours
PHYS 224	Modern Physics	3
PHYS 321	Classical Mechanics	3
PHYS 322	Electricity and Magnetism	3
PHYS 323	Statistical Mechanics	3
PHYS 324	Quantum Mechanics ¹	3
PHYS 424	Advanced Quantum Mechanics	3
PHYS 451	Fields, Oscs, and Relativity	3
PHYS 452	Optics	3
PHYS 454	Nuclear and Particle Physics ²	3
PHYS 455	Cosmology and Astrophysics	3
PHYS 456	Biophysical Systems and Modeling	3

² Require PHYS 224 Modern Physics, PHYS 321 Classical Mechanics, and PHYS 322 Electricity and Magnetism as prerequisites; PHYS 424 Advanced Quantum Mechanics requires PHYS 324 Quantum Mechanics as prerequisite

Math Electives:

- Cannot double-count with a required course.
- Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS: or MATH 499 Comprehensive for Mathematics as MATH electives.
- Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Statistics Electives list

Code	Title	Hours
CPSC 322	Data Science Algorithms	
CPSC 323	Machine Learning and Intelligent Systems	
ECON 355	Regression Analysis	
ECON 451	Econometrics	
ECON 452	Time Series Analysis	
MATH 421	Probability Theory	
MATH 422	Mathematical Statistics	
MATH 423	Stochastic Processes	
MATH 426	Experimental Design	

PHYS 323	Statistical Mechanics
PSYC 450	Advanced Statistics in Psychology
Or any course with significant probability or statistics content with approval of the Math Department Chair. All of these courses have prerequisites and may require courses outside of the concentration to be taken.	

Applied Mathematics Minor Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
MATH 259	Calculus and Analytic Geometry III	4
MATH 260	Ordinary Differential Equation	3
Upper Division		
MATH 335	Applied Linear Algebra	3
or MATH 339	Linear Algebra	
Select one of the following:		3
MATH 440	Foundations of Applied Math	
MATH 454	Partial Differential Equations	
MATH 462	Nonlinear Systems and Chaos	
MATH 300-400 level elective		
Applied Math Electives ¹		3
Total Hours		24

¹ **Math Electives:** cannot double-count with a required course. Cannot use MATH 335 Applied Linear Algebra, MATH 339 Linear Algebra, MATH 432 CIS:, MATH 496 Comprehensive for Applied Mathematics, or MATH 499 Comprehensive for Mathematics as MATH electives.
Maximum of three (3) total credits from the following may be counted toward Math electives: MATH 365 Math Seminar (may be taken for credit only once), MATH 390 Directed Study, MATH 490 Directed Reading, MATH 497 Mathematics Internship.

Mathematics Minor Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
MATH 259	Calculus and Analytic Geometry III	4
Upper Division		
MATH 301	Fundamentals of Mathematics	3
MATH 335	Applied Linear Algebra	3
or MATH 339	Linear Algebra	
MATH 300-400-level elective ¹		3
MATH 400-level elective		3
Total Hours		24

¹ This course may be replaced by MATH 260 Ordinary Differential Equation.

Statistics Minor Program Requirements

Code	Title	Hours
Lower Division		
MATH 157	Calculus and Analytic Geometry I	4
MATH 258	Calculus and Analytic Geometry II	4
Upper Division		
MATH 335 or MATH 339	Applied Linear Algebra Linear Algebra	3
MATH 321 or MATH 422	Statistics for Experimentalist Mathematical Statistics	3
MATH 425 or MATH 426	Applied Statistical Models Experimental Design	3
Statistics Electives: ¹		6
Total Hours		23

¹ One course must be MATH. Cannot double-count with courses used elsewhere.

Statistics Electives List

Code	Title	Hours
ECON 355	Regression Analysis	3
CPSC 322	Data Science Algorithms	3
CPSC 323	Machine Learning and Intelligent Systems	3
ECON 451	Econometrics	3
ECON 452	Time Series Analysis	3
MATH 421	Probability Theory	3
MATH 422	Mathematical Statistics	3
MATH 423	Stochastic Processes	3
MATH 426	Experimental Design	3
PHYS 323	Statistical Mechanics	3
PSYC 450	Advanced Statistics in Psychology	3

Or any course with significant probability or statistics content with approval of the Math Department Chair. All of these courses have prerequisites and may require courses outside of the concentration to be taken.

Courses

MATH 099. Intermediate Algebra. (3 Credits)

Review of basic algebraic operations and concepts for students who need additional preparation before taking other courses involving mathematics. Topics include operations on algebraic expressions, factoring, algebraic functions, linear and quadratic equations, graphing, exponents, radicals, and linear equations in two unknowns. This course does not fulfill the math requirement in the University Core.

MATH 100. College Algebra. (3 Credits)

College algebra for those students who need additional preparation before taking MATH 114, MATH 147, or MATH 148. Topics include equations, polynomials, conics, graphing, algebraic, exponential and logarithmic functions. This course does not fulfill the math requirement in the University Core. Fall and Spring.

Course Fee: 5

MATH 103. Excursions in Mathematics. (3 Credits)

An elementary survey of various mathematical areas such as algebra, geometry, counting (permutations, combinations), probability, and other topics selected by the instructor. This course is intended for the liberal arts student not pursuing business or the sciences. Fall and Spring.

Course Fee: 5

MATH 104. Elements of Algebra and Statistics. (3 Credits)

Development and application of concepts from algebra and statistics. Topics include polynomials, solving equations, graphing, functions, modeling, counting (permutations and combinations), data representation, probability, and statistics.

Course Fee: 5

MATH 114. Mathematical Analysis for Business. (3 Credits)

Designed for the student majoring in business. Topics selected from: functions and models, systems of equations, optimization, and introductory calculus. The emphasis will be on examples from business, which may include: cost, revenue, profit, supply, demand, market equilibrium, interest, present-value, future-value, and consumer and producer surplus. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Course Fee: 5

MATH 121. Introductory Statistics. (3 Credits)

An introduction to the basic concepts of descriptive and inferential statistics and their application to the interpretation and analysis of data. Fall and Spring.

Course Fee: 5

MATH 147. Precalculus. (3 Credits)

Topics include advanced equations and inequalities, functions and graphs including composite and inverse functions, logarithmic and exponential functions, trigonometric functions and their graphs, right angle trigonometry, trigonometric identities, systems of equations, and conics. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Course Fee: 5

MATH 148. Survey of Calculus. (3 Credits)

A one semester introduction to differential and integral calculus designed to convey the significance, use and application of calculus for liberal arts students, particularly those in the behavioral, biological, and social sciences. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Course Fee: 5

MATH 157. Calculus and Analytic Geometry I. (4 Credits)

An introduction to calculus for engineering, science and mathematics students, with an emphasis on conceptual understanding, problem solving, and modeling. Topics covered include: limits, continuity, derivatives of algebraic, trigonometric, and transcendental functions, applications of the derivative including optimization problems and linear approximations, antiderivatives, introduction to the definite integral, and the Fundamental Theorem of Calculus. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Equivalent: HONS 157

Course Fee: 5

MATH 180. Special Topics. (1-4 Credits)**May be repeated for credit.**

Topic to be determined by instructor.

Corequisites: MATH 157**MATH 193. FYS.: (3 Credits)**

The First-Year Seminar (FYS) introduces new Gonzaga students to the University, the Core Curriculum, and Gonzaga's Jesuit mission and heritage. While the seminars will be taught by faculty with expertise in particular disciplines, topics will be addressed in a way that illustrates approaches and methods of different academic disciplines. The seminar format of the course highlights the participatory character of university life, emphasizing that learning is an active, collegial process. This course does not meet major or minor requirements.

MATH 221. Applied Statistics. (3 Credits)

This course contains an introduction to probability and the use of statistics to solve problems in a variety of scientific disciplines. Topics include experimental design, sampling methods, confidence intervals, hypothesis tests, and linear models. The use of statistical software is integral to this course. Fall.

Prerequisites: Prerequisites exist. Refer to Zagweb.**Course Fee:** 5**MATH 231. Discrete Structures. (3 Credits)**

A study of propositional logic, set theory, functions, algorithms, divisibility, introductory number theory, elementary proof techniques, counting techniques, recursive definitions, mathematical induction, and graph theory. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.**Course Fee:** 5**MATH 258. Calculus and Analytic Geometry II. (4 Credits)**

A continuation of MATH 157. Topics covered are: techniques of integration, applications of the integral, improper integrals, sequences and infinite series with an introduction to convergence tests, parametric equations, and polar coordinates.

Prerequisites: Prerequisites exist. Refer to Zagweb.**Equivalent:** HONS 258**Course Fee:** 5**MATH 259. Calculus and Analytic Geometry III. (4 Credits)**

A treatment of multivariable calculus and the calculus of vector fields. Topics include: vectors and vector-valued functions, partial derivatives, multiple integration, curl and divergence, line integrals, Green's theorem, Stokes' theorem, and the Divergence theorem.

Prerequisites: Prerequisites exist. Refer to Zagweb.**Course Fee:** 5**MATH 260. Ordinary Differential Equation. (3 Credits)**

Solution methods for first-order equations, second-order linear equations, and linear systems of differential equations, including analytic and qualitative approaches. Topics include mathematical modeling, Laplace transforms, Taylor series solutions, and an introduction to matrix methods. Additional topics may include numerical methods, analyzing nonlinear systems, and techniques for higher-order linear equations. Fall and Spring.

Prerequisites: MATH 259 with a minimum grade of D**Course Fee:** 5**MATH 290. Directed Reading. (1-3 Credits)****May be repeated for credit.**

Readings and reports in selected mathematical topics. Upon sufficient demand.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Enrollment limited to students with a semester level of Second Year (26-59.99 credits).

MATH 301. Fundamentals of Mathematics. (3 Credits)

A development of the standard techniques of mathematical proof through an examination of logic, set theory, as well as one-to-one, onto, and inverse functions. Additional topics may be chosen from the topology of the real line, the cardinality of sets, basic number theory, and basic group theory. Fall and Spring.

Prerequisites: MATH 259 with a minimum grade of D**Equivalent:** HONS 311**MATH 321. Statistics for Experimentalist. (3 Credits)**

An applied statistics course for those with calculus preparation. Descriptive statistics, probability theory, discrete and continuous random variables, and methods of inferential statistics including interval estimation, hypothesis testing, and regression. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.**Course Fee:** 5**MATH 328. Operations Research. (3 Credits)**

Quantitative methods for application to problems from business, engineering, and the social sciences. Topics include linear and dynamic programming, transportation problems, network analysis, PERT, and game theory. Spring, odd years.

Prerequisites: Prerequisites exist. Refer to Zagweb.**MATH 335. Applied Linear Algebra. (3 Credits)**

An applied study of matrices, vector spaces, and linear transformations, with a focus on computations and modeling. Topics include linear systems, dependence and rank, bases, inner product spaces, orthogonal and orthonormal sets, eigenvalues and eigenvectors, matrix factorizations, and singular values. Additional topics may include numerical techniques and applications to static and dynamical physical systems, Markov chains, graph theory, artificial neural networks, image and signal processing. Computer programming will be an integral component of the class. Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.**MATH 339. Linear Algebra. (3 Credits)**

A systematic study of the theory of matrices, vector spaces, and linear transformations. Topics include systems of linear equations, determinants, linear independence, bases, dimension, rank, eigenvalues, and eigenvectors. Additional topics may include inner products, orthonormal bases, projections, and quadratic forms. Applications may include geometry, adjacency matrices, calculus, difference equations, least squares, and Markov chains. Some proof-writing expected. Fall and Spring.

Prerequisites: MATH 259 with a minimum grade of D or HONS 217**MATH 341. Modern Geometry. (3 Credits)**

Axiomatic systems for, and selected topics from, Euclidean geometry, projective geometry, and other non-Euclidean geometries. Special attention will be given to the needs of the individuals preparing to teach at the secondary level. Fall, even years.

Prerequisites: MATH 259 with a minimum grade of D

MATH 350. Numerical Methods. (3 Credits)

An introduction to approximating solutions to problems arising in applied mathematics and science. Topics include solving linear systems, root-finding, interpolations, regression, numerical integration and differentiation, and initial value problems. Computer programming will be an integral component of the class. Fall.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 351. Combinatorics and Graph Theory. (3 Credits)

An introduction to combinatorics and graph theory with topics taken from counting techniques, generating functions, combinatorial designs and codes, matchings, directed graphs, paths, circuits, connectivity, trees, planarity, and colorings. Fall, odd years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 360. Selected Topics. (1-3 Credits)

May be repeated for credit.

Various areas of pure and applied mathematics presented at a level accessible to those just completing calculus. Upon sufficient demand.

MATH 361. Selected Topics. (1-3 Credits)

May be repeated for credit.

Various areas of pure and applied mathematics presented at a level accessible to those just completing calculus. Upon sufficient demand.

MATH 362. Selected Topics. (1-3 Credits)

May be repeated for credit.

Various areas of pure and applied mathematics presented at a level accessible to those just completing calculus. Upon sufficient demand.

MATH 363. Selected Topics. (1-3 Credits)

May be repeated for credit.

Various areas of pure and applied mathematics presented at a level accessible to those just completing calculus. Upon sufficient demand.

MATH 365. Math Seminar. (1 Credit)

This seminar is intended to expose students with a calculus background to a wide variety of interesting topics and applications in mathematics. The goal of this seminar is to help students discover and explore topics in mathematics, not typically covered in a classroom setting. A weekly guest lecturer will present a topic or activity and invite questions and participation from the class. Guest lecturers may be faculty, students who have performed independent research, or guests from the community. Spring

Prerequisites: MATH 258 with a minimum grade of D

MATH 390. Directed Study. (1-3 Credits)

May be repeated for credit.

Topic to be determined by faculty.

MATH 413. Real Analysis I. (3 Credits)

This proof-based course provides a rigorous treatment of the real number system, the topology of the real line, sequences and series of numbers and functions, continuity of functions, differentiation, and the Riemann integral. Spring and Fall, even years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 414. Real Analysis II. (3 Credits)

Continuation of MATH 413 with topics chosen from Lebesgue theory, metric spaces, function spaces, and multivariable calculus. Spring, odd years.

Prerequisites: MATH 413 with a minimum grade of D

MATH 417. Complex Variables. (3 Credits)

An introduction to complex numbers and functions of one complex variable. Topics include the geometry and algebra of complex numbers, elementary functions, analytic functions, integration on the complex plane, Taylor and Laurent expansions, and the calculus of residues. Other topics selected from conformal mappings, integral transforms and inversion formulas, harmonic functions, and winding numbers, with applications to physical problems. Spring, even years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 421. Probability Theory. (3 Credits)

A mathematical treatment of the laws of probability with emphasis on those properties fundamental to mathematical statistics. General probability spaces, combinatorial analysis, random variables, conditional probability, moment generating functions, Bayes' law, distribution theory, and law of large numbers. Fall.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 422. Mathematical Statistics. (3 Credits)

An examination of the mathematical principles underlying the basic statistical inference techniques of estimation, hypothesis testing, regression and correlation, nonparametric statistics, analysis of variance. Spring, even years.

Prerequisites: MATH 421 with a minimum grade of D

MATH 423. Stochastic Processes. (3 Credits)

An introduction to random processes and their applications in scientific inquiry, including discrete and continuous time probability models, Markov chains, Poisson processes, random walks, and simulation techniques. Additional topics selected from: queuing theory, branching processes, reliability theory, and Brownian motion. Spring, odd years.

Prerequisites: MATH 421 with a minimum grade of D

MATH 425. Applied Statistical Models. (3 Credits)

The course covers a wide range of statistical models including simple and multiple linear regression for quantitative and qualitative variables, logistic regression, log-linear models, models for rates (Poisson regression), and non-linear regression models. Inferences and model adequacy checking, model selection, and validation will be covered. The emphasis is on the practical application of these methods using statistical software. Fall, even years.

Prerequisites: MATH 321 with a minimum grade of D or MATH 422 with a minimum grade of D

MATH 426. Experimental Design. (3 Credits)

This course covers ANOVA models without and with interactions, randomized block, Latin square, factorial, confounded factorial, balanced incomplete block, other designs. Working with simple linear regression models, random and mixed-effects models, response surface methodology are covered. The emphasis is on how to plan, design, and conduct experiments efficiently and effectively, and analyze the resulting data using statistical software. Fall, odd years.

Prerequisites: MATH 321 with a minimum grade of D or MATH 422 with a minimum grade of D

MATH 432. CIS: (3 Credits)

The Core Integration Seminar (CIS) engages the Year Four Question: "Imagining the possible: What is our role in the world?" by offering students a culminating seminar experience in which students integrate the principles of Jesuit education, prior components of the Core, and their disciplinary expertise. Each section of the course will focus on a problem or issue raised by the contemporary world that encourages integration, collaboration, and problem solving. The topic for each section of the course will be proposed and developed by each faculty member in a way that clearly connects to the Jesuit Mission, to multiple disciplinary perspectives, and to our students' future role in the world. This course does not meet major or minor requirements.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 437. Abstract Algebra I. (3 Credits)

A detailed examination of topics chosen from groups, rings, integral domains, Euclidean domains, unique factorization, fields, Galois theory, and solvability by radicals. Spring and Fall, odd years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 438. Abstract Algebra II. (3 Credits)

Continuation of MATH 437. Spring, even years.

Prerequisites: MATH 437 with a minimum grade of D

MATH 440. Foundations of Applied Math. (3 Credits)

This course introduces advanced foundational techniques used to solve problems arising in applied mathematics, science and engineering. Topics include dimensional analysis and scaling, mathematical modeling, perturbation methods, and asymptotic expansions. Additional topics may include the calculus of variations, similarity methods, integral transforms, Fourier series, special functions, and the derivation of models from conservation laws and constitutive equations; other topics may be selected at the discretion of the instructor. Fall, odd years.

Prerequisites: MATH 260 with a minimum grade of C-

MATH 450. Selected Topics. (1-3 Credits)

May be repeated for credit.

Possible topics include combinatorics, topology, number theory, advanced numerical analysis, advanced linear algebra, theory of computation and complexity, and history of mathematics. Credit by arrangement. Upon sufficient demand.

MATH 451. Special Topics. (1-3 Credits)

May be repeated for credit.

Possible topics include combinatorics, topology, number theory, advanced numerical analysis, advanced linear algebra, theory of computation and complexity, and history of mathematics. Credit by arrangement.

MATH 452. Selected Topics. (1-3 Credits)

May be repeated for credit.

Possible topics include combinatorics, topology, number theory, advanced numerical analysis, advanced linear algebra, theory of computation and complexity, and history of mathematics. Credit by arrangement. Upon sufficient demand.

MATH 453. Selected Topics. (1-3 Credits)

May be repeated for credit.

Possible topics include combinatorics, topology, number theory, advanced numerical analysis, advanced linear algebra, theory of computation and complexity, and history of mathematics. Credit by arrangement. Upon sufficient demand.

MATH 454. Partial Differential Equations. (3 Credits)

Solutions of boundary value problems with applications to heat flow, wave motion, and potential theory. Topics include derivation of the heat, wave, and Laplace's equations, orthogonal sets of functions, Fourier series, Sturm-Liouville theory, separation of variables, integral transforms, the method of characteristics, and extensions to higher dimensions and non-Cartesian coordinate systems. Additional topics may include numerical methods, inverse methods, and nonlinear equations. Spring.

Prerequisites: MATH 260 with a minimum grade of C-

MATH 455. Chaos and Discrete Dynamical Systems. (3 Credits)

Introduction to the study of one-dimensional discrete-time nonlinear systems and their potential for chaotic behavior. The course will focus on investigations through computer experiments - numerical and graphical - and the mathematical analysis of the observed behavior. Students are expected to write code in at least one high-level language. Topics include orbit analysis, fixed and periodic points, graphical analysis, bifurcations, symbolic dynamics, chaos, and fractals. Additional topics selected from dynamics in the complex plane, higher dimensional maps, numerical computation of Lyapunov exponents, fractal dimension, Sarkovskii's theorem, and chaos control. Spring, even years.

Prerequisites: (CPSC 121 with a minimum grade of C and MATH 350 with a minimum grade of D) or (MATH 231 with a minimum grade of C and CPSC 122 with a minimum grade of D)

Equivalent: CPSC 455

MATH 457. Number Theory and Cryptography. (3 Credits)

Elementary number theory topics including modular arithmetic, Diophantine equations, multiplicative functions, factorization techniques, primality testing, and development of the public key code. Additional topics may be included. Fall, even years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 459. Topology. (3 Credits)

Topics selected from the following: Metric spaces, manifolds, general topological spaces. Sequences, continuous functions, homeomorphisms. The separation axioms, connectedness, compactness. The theory of surfaces. Knot theory. Topics from combinatorial topology, algebraic topology, differential topology. Other topics to be determined by the instructor. Spring, odd years.

Prerequisites: Prerequisites exist. Refer to Zagweb.

MATH 462. Nonlinear Systems and Chaos. (3 Credits)

A study of nonlinear ordinary differential equations and systems of such equations, with a focus on approaching problems geometrically. Topics include phase space, equilibrium solutions, bifurcations, stability analysis, limit cycles, chaos, fractals, and strange attractors; other topics may be selected at the discretion of the instructor. Applications to problems in biology, chemistry, physics, engineering and other fields will be explored. Fall, even years.

Prerequisites: MATH 260 with a minimum grade of C-

MATH 490. Directed Reading. (0-4 Credits)

May be repeated for credit.

Selected topics in mathematics.

MATH 494. Topics in Actuarial Science. (1 Credit)

This course explores the application of mathematics to solving actuarial science problems. Course material is intended to help students prepare for the probability and financial math actuarial exams. Spring upon sufficient demand.

Prerequisites: MATH 421 with a minimum grade of C- and ECON 352L with a minimum grade of C-

MATH 496. Comprehensive for Applied Mathematics. (1 Credit)

A comprehensive survey of applied mathematics and its connections with various technical disciplines. Students will gain experience with both written and oral communication while reviewing a breadth of mathematical topics and exploring interdisciplinary applications. Students will be required to take the Educational Testing Service's Major Field Test in Mathematics. Required of all Applied Mathematics majors in their final year. Fall.

Course Fee: 35

Enrollment limited to students with a semester level of Fourth Year (96+ credits).

MATH 497. Mathematics Internship. (0-6 Credits)

Special program for Mathematics majors.

Enrollment limited to students with a semester level of Fourth Year (96+ credits).

MATH 498A. Thesis I. (1 Credit)

This course provides the motivated student with the opportunity to conduct an independent research project under the direction of a Mathematics Department faculty member. Rigorous research and study of advanced material with a significant technical writing component. Contingent on the student finding a faculty member in the Department of Mathematics who is willing to serve as a mentor. Fall and Spring.

Prerequisites: Prerequisites exist. Refer to Zagweb.

Enrollment limited to students with a semester level of Fourth Year (96+ credits) or Third Year (60-95.99 credits).

MATH 498B. Thesis II. (2 Credits)

Continuation of MATH 498A, culminating in a written thesis. Students are expected to present their work at a conference. Fall and Spring.

Prerequisites: MATH 498A with a minimum grade of B

MATH 499. Comprehensive for Mathematics. (1 Credit)

A comprehensive survey of mathematics. Students will gain experience with both written and oral communication of mathematics while reviewing a breadth of mathematical topics. Students will be required to take the Educational Testing Service's Major Field Test in Mathematics. Required of all Mathematics majors in their final year. Fall.

Course Fee: 35

Enrollment limited to students with a semester level of Fourth Year (96+ credits).