

Mathematics & Physics

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Chair of the Department

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The Department of Mathematics and Physics plays a vital role in the education of all students at Manhattan College through its offerings of programs for our majors as well as through the many support courses it offers for other departments across the college.

We provide each student the analytical skills necessary to be successful in their field of study, whether it is Mathematics or Physics, another STEM field, Business, Education or the Liberal Arts.

MATHEMATICS

Mathematics is the science of structure and the art of problem solving. The discipline is at the core of every STEM field, is at the heart of decision making in business, and has applications in all of the liberal arts. Studying mathematics will give you the critical-thinking and analytical skills needed for a career in data science, STEM education, law, finance, and more.

Majors receive rigorous training in the areas of analysis, linear and abstract algebra, statistics, and mathematical proof-writing. Students have the opportunity to gain experience in applied subjects such as data science, operations research, and mathematical modeling. Our faculty are distinguished scientists and award-winning educators. Students will be encouraged to participate in mentored research projects, many of which are funded experiences, that provide preparation for graduate school as well as successful careers in industry. Mathematics students have presented their work at national and international conferences, and several have co-authored peer-reviewed publications with their faculty mentors.

The Department supports a chapter of Pi Mu Epsilon, the national mathematics honor society, and Sigma Xi, an international honor society for science and engineering.

Degree Plans

The Department offers the following degree programs:

- Major in Mathematics
 - Bachelor of Science Degree
 - Bachelor of Arts Degree
- Second Major in Mathematics
- Concentration in Applied Mathematics
- Minor in Mathematics

The Department works closely with the Dept. of Education on the requirements for the B.S. in Adolescence Education Mathematics, which prepares students to teach at the secondary level, and the Mathematics emphasis in the B.S. in Childhood Education, which prepares students to teach at the elementary level.

General Requirements

Courses should be taken in accordance with the Plans of Study listed below. These plans incorporate the Kakos School of Arts and Science Core Curriculum. Care should be taken in planning your program since some courses are not offered every semester. A minimum grade of C is required in each of the courses used for any of the listed programs (major, second major, concentration, or minor).

With the approval of the Department Chair, well-prepared undergraduate students can take graduate mathematics courses to count toward their mathematics electives.

Major in Mathematics

B.S. in Mathematics

MATH 157	Foundations of Data Science	3
or CMPT 102	Computer Science II	
MATH 185	Calculus I ¹	4
MATH 186	Calculus II ¹	4
MATH 243	Foundations for Higher Mathematics	3
MATH 285	Calculus III ¹	4
MATH 331	Probability	3
MATH 336	Applied Statistics	3
MATH 372	Linear Algebra I	3
MATH 377	Algebra I	3
MATH 387	Analysis I	3
MATH 489	Problem Seminar	3
MATH Electives ²		6
CMPT 101	Computer Science I	3
PHYS 101 & PHYS 191	Physics I and Physics I Lab	4
PHYS 102 & PHYS 192	Physics II and Physics II Lab	4
Natural Sciences		8
Total Credits		61

¹ Students who major in Mathematics and are selected for the honors sequence will be enrolled in the honors sections of Calculus I, II, and III (MATH 187, 188, and 287).

² MATH Electives can be taken from the following list of Mathematics courses: 286, 361, 386, 432, 433, 448, 455, 456, 457, 464, 471, 478, 488, 490, and select topics

courses by permission of the Chair. Graduate mathematics courses can also be used as electives with approval of the Chair.

B.A. in Mathematics

MATH 157	Foundations of Data Science	3
or CMPT 102	Computer Science II	
MATH 185	Calculus I ¹	4
MATH 186	Calculus II ¹	4
MATH 243	Foundations for Higher Mathematics	3
MATH 285	Calculus III ¹	4
MATH 331	Probability	3
MATH 336	Applied Statistics	3
MATH 372	Linear Algebra I	3
MATH 377	Algebra I	3
MATH 387	Analysis I	3
MATH 489	Problem Seminar	3
MATH Electives ²		6
CMPT 101	Computer Science I	3
3 SCI Courses ³		9
Total Credits		54

¹ *Students who major in Mathematics and are selected for the honors sequence will be enrolled in the honors sections of Calculus I, II, and III (MATH 187, 188, and 287).*

² *MATH Electives can be taken from the following list of Mathematics courses: 286, 361, 386, 432, 433, 448, 455, 456, 457, 464, 471, 478, 488, 490, and select topics courses by permission of the Chair. Graduate mathematics courses can also be used as electives with approval of the Chair.*

³ *Students may opt for one full year of a lab science (8 credits). Students may also opt to replace the 3 SCI XXX courses with 9 credits of courses within a single discipline in the School of Science.*

Second Major in Mathematics

Students with a primary major in Liberal Arts, Business, Engineering, or Science

To complete a second major in Mathematics, students with a primary major in one of the above areas must take a total of 39 credits of mathematics courses from the Mathematics major courses listed above. These credits must include MATH 157 (or CMPT 102), MATH 185 (or 187), 186 (or 188), 243, 285 (or 287), 336, 372, 377, 387, MATH 489, and two (2) MATH electives. Graduate Mathematics courses also may be used as electives with approval of the Department Chair.

Students majoring in Adolescence Education

Students pursuing a degree in Adolescence Education Mathematics earn a Second Major in Mathematics by completing the following sequence as required by their degree program.

B.S. in Adolescence Education Mathematics

MATH 157 or CMPT 102	Foundations of Data Science Computer Science II	3
MATH 185	Calculus I	4
MATH 186	Calculus II	4
MATH 243	Foundations for Higher Mathematics	3
MATH 285	Calculus III	4
MATH 328	Fundamental Concepts of Secondary Mathematics	3
MATH 331	Probability	3
MATH 336	Applied Statistics	3
MATH 361	Introduction to Higher Geometry	3
MATH 372	Linear Algebra I	3
MATH 377	Algebra I	3
MATH 387	Analysis I	3
MATH 489	Problem Seminar	3
CMPT 101	Computer Science I	3
Total Credits		45

* *Sequencing of courses is very important in order to accommodate the requirements of student teaching.*

Application: A student who wishes to declare a Second Major in Mathematics should consult with the Chair of Mathematics and Physics, who will advise them on curricular matters. Advice on administrative procedures is offered through the Office of Centralized Advising.

A grade of at least C is required for all courses meeting the requirements for a Second Major in Mathematics.

Concentration in Applied Mathematics

The Concentration in Applied Mathematics is designed to complement major study in a different discipline and prepare students to use mathematics in the workplace. The concentration requires 7 courses (24 credits), providing more depth than the minor in Mathematics. A grade of at least C is required for all courses meeting the requirements for a Concentration in Applied Mathematics.

The required core of 15 credits, comprised of Calculus I-II-III (MATH 185/187, 186/188, 285/287) and Linear Algebra I (MATH 372)/Computational Linear Algebra & Statistics for Computer Science (MATH 351). Students choose the remaining 9 credits from a list of approved courses, including Foundations of Data Science (MATH 157), Differential Equations (MATH 286), Probability (MATH 331), Applied Statistics (MATH 336), Partial Differential Equations (MATH 386), Machine Learning (MATH 457/MATG 557),

Operations Research (MATH 455/MATG 555), Mathematical Modeling (MATH 456), Linear Algebra II (MATH 471)/Advanced Linear Algebra with Applications (MATG 571), and Complex Analysis (MATH 490). Special topics courses in Mathematics or Graduate Mathematics courses may be used with approval of the Department Chair.

Completion of the Concentration will be documented on the student's transcript.

Application: A student who wishes to declare a Concentration in Applied Mathematics should consult with the Assistant Chair of Mathematics and Physics, who will advise them on curricular matters. Advice on administrative procedures is offered through the Office of Centralized Advising.

Minor in Mathematics

The minor in Mathematics consists of 5 courses in Mathematics and must include Calculus I (MATH 155/185/187) and Calculus II (MATH 156/186/188). The remaining courses may be chosen from among those that count toward a major in Mathematics. A grade of at least C is required for all courses meeting the requirements for a minor in Mathematics. At least three courses must be taken at Manhattan College, with AP and/or transfer credit subject to approval by the Chair of the Department of Mathematics and Physics.

Note: The following courses may **not** be used toward the Mathematics minor: MATH 100, 111, 151, 153, 154, 157, 158, 221, 222, 230, 320, 321, 322, 326, 327, 328, and 422.

Application: A student who wishes to declare a Minor in Mathematics should seek advice on administrative procedures through the Office of Centralized Advising. The Chair and Assistant Chair of Mathematics and Physics are available for consultation on curricular matters.

B.S. in Childhood Education - Mathematics Concentration

All students majoring in Childhood Education take the following 6 credit core sequence.

MATH 221	Mathematics for the Elementary School Teachers I	3
MATH 222	Mathematics for the Elementary School Teachers II	3

Childhood Education majors who pursue a Concentration in Mathematics take an additional 30 credits in Mathematics, including Precalculus (MATH 100), Calculus I (MATH 155/185/187), Calculus II (MATH 156/186/188), Foundations of Higher Mathematics (MATH 243), Foundations of Childhood Mathematics (MATH 327), a course in Statistics (MATH 230 or MATH 336), and three from the following: MATH 157, MATH 285, MATH 328, MATH 361, MATH 372. Please see the Plan of Study below for the appropriate sequencing of these courses.

PLANS OF STUDY

Bachelor of Science in Mathematics

First Year

Fall	Credits	Spring	Credits
MATH 185		4 MATH 157 ²	3
CMPT 101		3 MATH 186	4
Modern Language ¹		3 Modern Language ¹	3
ENGL 110		3 RELS 110	3
SCI 100		1 LLRN 105	3
Social Science		3	
	17		16

Second Year

Fall	Credits	Spring	Credits
MATH 243		3 MATH 336	3
MATH 285		4 MATH 372	3
PHYS 101 & PHYS 191		4 PHYS 102 & PHYS 192	4
PHIL 150		3 ENGL 150	3
Free Elective		3 Free Elective	3
	17		16

Third Year

Fall	Credits	Spring	Credits
MATH 331		3 MATH 387	3
MATH 377		3 RELS 2XX Catholic Studies	3
Natural Science ³		4 Natural Science ³	4
HIST 150		3 MATH Elective	3
Free Elective		3 Free Elective	3
	16		16

Fourth Year

Fall	Credits	Spring	Credits
MATH Elective		3 MATH 489	3
Free Electives		6 Free Electives	9
MUSC 150 or ART 150		3 RELS 3XX Global/Contemporary	3
	12		15

Total Credits: 125

¹ One year sequence of a Modern Foreign Language.

² Students wishing to minor in Computer Science should take CMPT 102 Computer Science II instead of MATH 157 Foundations of Data Science.

³ One year (8 credits with lab) of the same natural science is required.

Bachelor of Arts in Mathematics

First Year

Fall	Credits	Spring	Credits
MATH 185		4 MATH 157 ²	3
CMPT 101		3 MATH 186	4
Modern Language ¹		3 Modern Language ¹	3
ENGL 110		3 RELS 110	3
SCI 100		1 LLRN 105	3
Social Science		3	
	17		16

Second Year

Fall	Credits	Spring	Credits
MATH 243		3 MATH 336	3
MATH 285		4 MATH 372	3
SCI XXX ³		3 SCI XXX ³	3
PHIL 150		3 SCI XXX ³	3
Free Elective		3 ENGL 150	3
	16		15

Third Year

Fall	Credits	Spring	Credits
MATH 331		3 MATH 387	3
MATH 377		3 RELS 2XX Catholic Studies	3
HIST 150		3 MATH Elective	3
Free Elective		6 Free Elective	6
	15		15

Fourth Year

Fall	Credits	Spring	Credits
MATH Elective		3 MATH 489	3
MUSC 150 or ART 150		3 RELS 3XX Global/Contemporary	3
Social Science		3 Free Electives	9
Free Electives		6	
	15		15

Total Credits: 124

¹ One year sequence of a Modern Foreign Language.

² Students wishing to minor in Computer Science should take CMPT 102 Computer Science II instead of MATH 157 Foundations of Data Science.

³ Students may opt for one full year of a lab science (8 credits). In this case, the student will graduate with 120 credits. Students may also opt to replace SCI XXX with 9 credits of courses from within a single discipline in the School of Science.

Bachelor of Science Adolescence Education Mathematics

Sequencing of Mathematics Courses

See Education (<http://catalog.manhattan.edu/undergraduate/artsandscience/education/>) for sequencing of Education Courses.

First Year

Fall	Credits	Spring	Credits
MATH 185		4 MATH 157 ¹	3
CMPT 101		3 MATH 186	4
		7	7

Second Year

Fall	Credits	Spring	Credits
MATH 243		3 MATH 328 ²	3
MATH 285		4 MATH 372	3
		7	6

Third Year

Fall	Credits	Spring	Credits
MATH 331		3 MATH 387	3
MATH 377		3 MATH 361 ²	3
		6	6

Fourth Year

		Spring	Credits
		MATH 336	3
		MATH 489	3
		6	

Total Credits: 45

¹ Students wishing to minor in Computer Science should take CMPT 102 Computer Science II instead of MATH 157 Foundations of Data Science.

² This plan of study applies to students who enter the program as first-year students in the fall of an even year. Students who enter the program as first-year students in the fall of an odd year will take MATH 361 in Year 2 and MATH 328 in Year 3.

Bachelor of Science Childhood Education Mathematics

Sequencing of Mathematics Courses

See Education (<http://catalog.manhattan.edu/undergraduate/artsandscience/education/>) for sequencing of Education Courses.

First Year

Fall	Credits	Spring	Credits
MATH 221 ¹		3 MATH 100	4
		MATH 222 ¹	3
		3	7

Second Year

Fall	Credits	Spring	Credits
MATH 185		4 MATH 186	4
MATH 327	3		
		7	4

Third Year

Fall	Credits	Spring	Credits
MATH 243		3 MATH 230 or 336	3
		MATH Elective	3
		3	6

Fourth Year

Fall	Credits	Spring	Credits
Student Teaching		MATH Elective	3
		MATH Elective	3
		0	6

Total Credits: 36

¹ MATH 221 and MATH 222 are required for all Childhood Education majors. These courses are not included in the 30-Hour Concentration in Mathematics. Rather, they are shown here to add context for the sequencing of the Concentration courses.

PHYSICS & ASTRONOMY

Physics is the study of natural phenomena, from subatomic scales to the scale of the entire universe. Physics is the most basic and fundamental science, and provides the basis for deep understanding in many fields of study and all of technology.

The Department offers B.S. and B.A. degrees in Physics, a Minor in Physics, a Minor in Astronomy and a Concentration in Theoretical Physics. Small class sizes and close collaboration between students and faculty create comfortable learning and research environments. Students in the Department collaborate with faculty on a variety of topics from early universe cosmology and neutron star astrophysics to particle physics, optics

and condensed matter. Our students publish articles in leading research journals and make presentations at national and international conferences. With support from the Department and Manhattan College they participate in research and internships during the academic year and over the summer, both on campus and at locations such as Brookhaven National Laboratory (USA) and CERN (Switzerland). Our alumni have successful careers in science, data science, teaching, engineering, medicine, finance and other fields.

Lower Division Requirements

All physics majors must take the following courses in their freshman and sophomore years:

PHYS 101 & PHYS 191	Physics I and Physics I Lab	4
PHYS 102 & PHYS 192	Physics II and Physics II Lab	4
PHYS 209	Mathematical Methods in Physics	3
PHYS 233	Physics III	3
PHYS 234	Physics IV	3
PHYS 262	Intermediate Laboratory II	1
PHYS 301	Computational Physics ^{BS program}	3
SCI 100	Science Orientation Seminar I	1
CMPT 101	Computer Science I	3
MATH 185 or MATH 187 or MATH 155	Calculus I Honors Calculus I Calculus for the Life Sciences I	4
MATH 186 or MATH 188 or MATH 156	Calculus II Honors Calculus II Calculus for the Life Sciences II	4
MATH 285 or MATH 287	Calculus III Honors Calculus III	4
MATH 286	Differential Equations	3
CHEM 101 & CHEM 103	General Chemistry I and General Chemistry Laboratory I	4
CHEM 102 & CHEM 104	General Chemistry II and General Chemistry Laboratory II	4

Upper Division Requirements for the B.S. Major in Physics

The B.S. Physics major program is standard preparation for those students interested in graduate studies in physics.

PHYS 312	Quantum Mechanics I	3
PHYS 314	Electromagnetic Waves	3

PHYS 341	Topics in Astrophysics	3
PHYS 350	Optics	3
PHYS 352	Modern Physics Lab II	3
PHYS 410	Advanced Theoretical Physics	3
PHYS 415	Statistical Mechanics	3
PHYS 440	Research Project in Physics	3
PHYS 443	Quantum Mechanics II: Quantum Computing & Information	3
PHYS 445	Research Project in Physics	2
PHYS 450	Seminar	1
PHYS 446	Topics in Cosmology	3

Upper Division Requirements for the B.A. Major in Physics

The B.A. Physics major program is useful to those interested in careers in fields such as education, technical writing, and patent law. It also provides a full foundation for graduate studies in physics.

PHYS 301	Computational Physics	3
PHYS 312	Quantum Mechanics I	3
PHYS 314	Electromagnetic Waves	3
PHYS 350	Optics	3
PHYS 352	Modern Physics Lab II	3
PHYS 415	Statistical Mechanics	3
PHYS 441	Senior Thesis	3
PHYS 446	Topics in Cosmology	3

Grade Requirements

For graduation, a physics major must have a 2.00 cumulative index in all required physics courses and elective science and engineering courses. A minimum grade of C is required in all major courses.

Minor in Physics

The minor in Physics consists of a minimum of 15 credits. Specific requirements are listed below. A grade of at least C is required for all courses meeting the requirements for a minor in Physics.

Application: To pursue the minor in Physics, a student must get a Minor Form from the department secretary, fill it out, and have it approved by the Chair of the Department. An approved form will be forwarded to the appropriate Dean.

Minor Requirements

The minor in Physics consists of a minimum of 15 credits including PHYS 101+191 and PHYS 102+192. The remaining courses should be chosen from the list below, with the approval of the Chair of the Department.

The following upper-level courses may be used toward the Physics minor: PHYS 209, 221, 233, 234, 262, 301, 312, 314, 341, 350, 352, 410, 415, 440, 443, 445, 446 and 450.

Minor in Astronomy

The minor in Astronomy consists of a minimum of 15 credits. Specific requirements are listed below. A grade of at least C is required for all courses meeting the requirements for a minor in Astronomy.

Application: To pursue the minor in Astronomy, a student must get a Minor Form from the department secretary, fill it out, and have it approved by the Chair of the Department. An approved form will be forwarded to the appropriate Dean.

Minor Requirements

Required 3 credits courses: PHYS 101, 102, 222, 341.

At least one of the following 3 credits upper-level courses offered by the Department is required: PHYS 301, 312, 314, 350, 440, and 446.

The Concentration in Theoretical Physics

The concentration in Theoretical Physics offers students the opportunity to acquire a deep conceptual understanding of fundamental physics and provides a foundation for professional work not only in physics and related fields but also in such fields as astrophysics, biophysics, engineering and applied physics, geophysics, mathematical physics, computer science, finance, and medicine. This concentration includes the following courses: Quantum Mechanics I (PHYS 312), Quantum Mechanics II (PHYS 443) and Advanced Theoretical Physics (PHYS 410).

PLANS OF STUDY

Bachelor of Science in Physics

Freshman

Fall	Credits	Spring	Credits
PHYS 101 & PHYS 191		4 PHYS 102 & PHYS 192	4
MATH 185 (Or MATH 187 or MATH 155)		4 MATH 186 (Or MATH 188 or MATH 156)	4
RELS 110		3 CMPT 101	3
SCI 100		1 ENGL 150	3
ENGL 110		3	
	15		14

Sophomore

Fall	Credits	Spring	Credits
PHYS 233		3 PHYS 234	3
PHYS 209		3 PHYS 262	1
MATH 285 or 287		4 PHYS 301	3

CHEM 101 & CHEM 103	4	MATH 286	3
Modern Language	3	CHEM 102 & CHEM 104 Modern Language	4 3
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	17		17

Junior

Fall	Credits	Spring	Credits
PHYS 350 or 446		3 PHYS 312	3
PHYS 352 ^{odd years}		3 PHYS 314 or 415	3
MUSC 150 or ART 150		3 PHYS 341 or 410	3
LLRN 105		3 PHIL 150	3
RELS Catholic Studies		3 RELS Global/Contemporary	3
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	15		15

Senior

Fall	Credits	Spring	Credits
PHYS 446 or 350		3 PHYS 410 or 341	3
PHYS 440		3 PHYS 415 or 314	3
PHYS 443		3 PHYS 445	2
Social Sciences		3 PHYS 450	1
Electives		3 HIST 150	3
		Social Sciences	3
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	15		15

Total Credits: 123

Bachelor of Arts in Physics

Freshman

Fall	Credits	Spring	Credits
PHYS 101 & PHYS 191		4 PHYS 102 & PHYS 192	4
MATH 185, 187, or 155		4 MATH 185, 188, or 156	4
RELS 110		3 CMPT 101	3
SCI 100		1 ENGL 150	3
ENGL 110		3	
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	15		14

Sophomore

Fall	Credits	Spring	Credits
PHYS 233		3 PHYS 234	3
PHYS 209		3 PHYS 262	1
MATH 285 or 287		4 MATH 286	3

CHEM 101 & CHEM 103	4 CHEM 102 & CHEM 104	4
Modern Language	3 Modern Language	3
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	17	14

Junior

Fall	Credits	Spring	Credits
PHYS 350 or 446		3 PHYS 301	3
PHYS 352 ^{odd years}		3 PHYS 314 or 415	3
HIST 150		3 PHIL 150	3
Electives		6 RELS Catholic Studies Electives	3 3
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	15		15

Senior

Fall	Credits	Spring	Credits
PHYS 446 or 350		3 PHYS 312	3
RELS Global/Contemporary		3 PHYS 441	3
Social Sciences		3 Social Sciences	3
Electives		6 Electives	6
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	15		15

Total Credits: 120