

# THEORETICAL PHYSICS AND APPLIED MATHEMATICS/MATHEMATICS (BS/MS)

The accelerated BS/MS program gives academically successful Loyola undergraduates the opportunity to pursue the MS degree in Mathematics while completing their BS degree. Since the advent of statistical mechanics, quantum mechanics, and the like, a solid foundation in analysis, abstract algebra, and statistics is essential for students wishing to study the basic physical laws governing our universe. Students pursuing a BS in Theoretical Physics and Applied Mathematics with gain exposure to these modern physical theories and to the abstract mathematics underpinning them.

There are several advantages to pursuing the BS/MS program. Chief among them are time and cost: by taking graduate courses during their senior year (at the undergraduate tuition rate), students in the BS/MS program save one semester over the usual path to a Master's degree. Additionally, students in the STEM fields holding an MS degree are more competitive for jobs.

## CURRICULUM

The following are required to complete this accelerated bachelor's/master's program:

- Successful completion of the Theoretical Physics and Applied Mathematics BS, within the College of Arts & Sciences.
- Successful completion of the 30-credit Mathematics MS degree with a GPA of 3.0 or higher.

Students in the BS/MS program are permitted to take up to 10 credit hours of 400-level courses that would apply toward their MS program requirements while completing their undergraduate degree. Of these, nine credits may come 400-level courses that have 300-level equivalents that satisfy BS program requirements. The one-credit course MATH 401 should also be taken during the student's undergraduate career. (While it does not fulfill any specific undergraduate program requirement, it does count towards the credit-hours requirement for a degree from the College of Arts & Sciences.)

Code	Title	Hours
<b>BS Requirements</b>		
<b>Mathematics Course Requirements</b>		
MATH 161	Calculus I	4
MATH 162	Calculus II	4
MATH 201	Introduction to Discrete Mathematics & Number Theory	3
MATH 212	Linear Algebra	3
MATH 263	Multivariable Calculus	4
MATH 264	Ordinary Differential Equations	3
MATH 313	Abstract Algebra	3
MATH 351	Introduction to Real Analysis I	3
MATH 353	Introductory Complex Analysis	3
PHYS 130	Introduction to Computational Physics	3
or MATH 215	Object-Oriented Programming with Mathematics	
<b>Physics Course Requirements</b>		

PHYS 121	College Physics I with Calculus Lecture/Discussion	3
PHYS 111L	College Physics Laboratory I	1
PHYS 122	College Physics II with Calculus Lecture/Discussion	3
PHYS 112L	College Physics Lab II	1
PHYS 126F	Freshman Projects	1
PHYS 235	Modern Physics	3
PHYS 235L	Modern Physics Laboratory	1
PHYS 301	Mathematical Methods in Physics	3
PHYS 314	Theoretical Mechanics I	3
PHYS 351	Electricity and Magnetism I	3
PHYS 328	Thermal Physical & Statistical Mechanics	3
PHYS 338	Advanced Physics Laboratory	2
PHYS 361	Quantum Mechanics I	3

### MS Requirements

#### Foundational Requirements

MATH 416	Survey of Algebra	3
MATH 454	Survey of Analysis	3
STAT 404	Probability & Statistics I	3
or STAT 408	Applied Regression Analysis	

#### Depth Requirements

A second course in algebra or analysis chosen from:		3
MATH 414	Algebra II	
MATH 415	Topics in Linear Algebra	
MATH 452	Analysis II	
MATH 453	Complex Analysis	
A second course in statistics or a cognate field chosen from:		3
STAT 404	Probability & Statistics I	
STAT 405	Probability & Statistics II	
STAT 408	Applied Regression Analysis	
STAT 410	Categorical Data Analysis	
COMP 429	Natural Language Processing	
COMP 487	Deep Learning	
DSCI 401	Introduction to Data Science	
Or courses in other programs, with approval		

#### Additional Requirements

MATH 401	Introduction to Graduate Study in Mathematics	1
MATH 495	Graduate Practicum in Mathematics	2

#### Mathematics & Statistics Electives

Four electives chosen from Mathematics and approved Statistics courses at the 400 level.<sup>1</sup>

**Total Hours** **93**

<sup>1</sup> A list of possible elective courses may be found here (<https://catalog.luc.edu/graduate-professional/graduate-school/arts-sciences/mathematics-statistics/#coursestext>).

## Suggested Sequence of Courses

The below sequence of courses is meant to be used as a suggested path for completing coursework. An individual student's completion of requirements depends on course offerings in a given term as well as the

start term for a major or graduate study. Students should consult their advisor for assistance with course selection.

Course	Title	Hours
<b>First Year</b>		
<b>Fall</b>		
PHYS 121	College Physics I with Calculus Lecture/ Discussion	3
PHYS 111L	College Physics Laboratory I	1
MATH 161	Calculus I	4
UCWR 110	Writing Responsibly	3
Core		3
<b>Hours</b>		<b>14</b>
<b>Spring</b>		
PHYS 122	College Physics II with Calculus Lecture/ Discussion	3
PHYS 112L	College Physics Lab II	1
PHYS 126F	Freshman Projects	1
MATH 162	Calculus II	4
COMP 215 / MATH 215 or PHYS 130	Object Oriented Programming with Mathematics or Introduction to Computational Physics	3
Core		3
<b>Hours</b>		<b>15</b>
<b>Second Year</b>		
<b>Fall</b>		
PHYS 235	Modern Physics	3
PHYS 235L	Modern Physics Laboratory	1
MATH 263	Multivariable Calculus	4
MATH 264	Ordinary Differential Equations	3
Core		3
<b>Hours</b>		<b>14</b>
<b>Spring</b>		
MATH 201	Introduction to Discrete Mathematics & Number Theory	3
MATH 212	Linear Algebra	3
PHYS 314	Theoretical Mechanics I	3
PHYS 301	Mathematical Methods in Physics	3
Core		3
<b>Hours</b>		<b>15</b>
<b>Third Year</b>		
<b>Fall</b>		
PHYS 351	Electricity and Magnetism I	3
MATH 313	Abstract Algebra	3
MATH 351	Introduction to Real Analysis I	3
Core		3
General Elective		3
<b>Hours</b>		<b>15</b>
<b>Spring</b>		
PHYS 361	Quantum Mechanics I	3
Core		3
Core		3
Core		3

General Elective		3
<b>Hours</b>		<b>15</b>
<b>Fourth Year</b>		
<b>Fall</b>		
MATH 353	Introductory Complex Analysis	3
PHYS 328	Thermal Physical & Statistical Mechanics	3
Core		3
Core		3
Core		3
<b>Hours</b>		<b>15</b>
<b>Spring</b>		
PHYS 338	Advanced Physics Laboratory	2
Core		3
Core		3
400-level Major Course		3
400-level Major Course		3
400-level Major Course		3
<b>Hours</b>		<b>17</b>
<b>Fifth Year</b>		
Complete MS requirements in consultation with the Graduate Program Director.		21
<b>Hours</b>		<b>21</b>
<b>Total Hours</b>		<b>141</b>

## Program Policies

- AP Credit Policies (<https://catalog.luc.edu/undergraduate/arts-sciences/mathematics-statistics/#policiestext>)
- No 300-level courses will apply toward graduate requirements.
- A student with credit for a 300-level MATH/STAT/COMP course that has an equivalent 400-level offering may not take the 400-level course for separate credit.

## Guidelines for Accelerated Bachelor's/ Master's Programs

### Terms

- **Accelerated Bachelor's/Master's programs:** In this type of program, students share limited credits between their undergraduate and graduate degrees to facilitate completion of both degrees.
- **Shared credits:** Graduate level credit hours taken during the undergraduate program and then applied towards graduate program requirements will be referred to as shared credits.

### Admission Requirements

Accelerated Bachelor's/Master's programs are designed to enhance opportunities for advanced training for Loyola's undergraduates. Admission to these programs must be competitive and will depend upon a positive review of credentials by the program's admissions committee. Accordingly, the admission requirements for these programs may be higher than those required if the master's degree were pursued entirely after the receipt of a bachelor's degree. That is, programs may choose to have more stringent admissions requirements in addition to those minimal requirements below.

Requirements:

- Declared appropriate undergraduate major,
- By the time students begin taking graduate courses as an undergraduate, the student has completed approximately 90 credit hours, or the credit hours required in a program that is accredited by a specialty organization,<sup>1</sup>
- A minimum cumulative GPA for coursework at Loyola that is at or above the program-specific requirements, a minimum major GPA that is at or above the program-specific requirements, and/or appropriate designated coursework for evaluation of student readiness in their discipline.<sup>2</sup>

Students not eligible for the Accelerated Bachelor's/Master's program (e.g., students who have not declared the appropriate undergraduate major) may apply to the master's program through the regular admissions process. Students enrolled in an Accelerated Bachelor's/Master's program who choose not to continue to the master's degree program upon completion of the bachelor's degree will face no consequences.<sup>3</sup>

Ideally, a student will apply for admission (or confirm interest in proceeding towards the graduate degree in opt-out programs) as they approach 90 credit hours. Programs are encouraged to begin advising students early in their major so that they are aware of the program and, if interested, can complete their bachelor's degree requirements in a way that facilitates completion of the program. Once admitted as an undergraduate, Program Directors should ensure that students are enrolled using the plan code associated with the Accelerated Bachelor's/Master's program. Using the plan code associated with the Accelerated Bachelor's/Master's program will ensure that students may be easily identified as they move through the program. Students will not officially matriculate into the master's degree program and be labeled as a graduate student by the university, with accompanying changes to tuition and Financial Aid (see below), until the undergraduate degree has been awarded. Once admitted to the graduate program, students must meet the academic standing requirements of their graduate program as they complete the program curriculum.

- <sup>1</sup> Programs that have specialized accreditation will adhere to the admissions criteria provided by, or approved by, their specialized accreditors.
- <sup>2</sup> The program will identify appropriate indicators of student readiness for graduate coursework (e.g., high-level performance in 300 level courses). Recognizing differences between how majors are designed, we do not specify a blanket requirement.
- <sup>3</sup> If students choose not to enroll in the Accelerated Bachelor's/Master's program, they still must complete all of the standard requirements associated with the undergraduate degree (e.g., a capstone).

For more information on Admissions requirements, visit here (<https://gpem.luc.edu/portal/admission/?tab=home>).

## Curriculum

*Level and progression of courses.* The Accelerated Bachelor's/Master's programs are designed to be competitive and attractive to our most capable students. Students admitted to Accelerated Bachelor's/Master's programs should be capable of meeting graduate level learning outcomes. Following guidance from the Higher Learning Commission, only courses taken at the 400 level or higher (including 300/400 level courses taken at the 400 level) will count toward the graduate program.<sup>1,2</sup>

Up to 50% of the total graduate level credit hours, required in the graduate program, may come from 300/400 level courses where the student is enrolled in the 400 level of the course. Further, at least 50% of the credit hours for the graduate program must come from courses

that are designed for and restricted to graduate students who have been admitted to a graduate program at Loyola (e.g., enrolled in plan code that indicates the Accelerated Bachelor's/Master's program, typically ending with the letter "D").<sup>3</sup>

In general, graduate level coursework should not be taken prior to admission into the Accelerated Bachelor's/Master's program. Exceptions may be granted for professional programs where curriculum for the Accelerated Bachelor's/Master's program is designed to begin earlier. On the recommendation of the program's Graduate Director, students may take one of their graduate level courses before they are admitted to the Accelerated Bachelors/Master's program if they have advanced abilities in their discipline and course offerings warrant such an exception.<sup>4</sup> Undergraduate degree requirements outside of the major are in no way impacted by admission to an Accelerated Bachelor's/Master's program.<sup>5</sup>

*Shared credits.* Undergraduate courses (i.e., courses offered at the 300 level or below) cannot be counted as shared credits nor count towards the master's degree. Up to 50% of the total graduate level credit hours, required in the graduate program, may be counted in meeting both the undergraduate and graduate degree requirements. Of those shared credits, students in an Accelerated Bachelor's/Master's program should begin their graduate program with the standard introductory course(s) for the program whenever possible. So that students may progress through the Accelerated Bachelor's/Master's program in a timely manner, undergraduate programs are encouraged to design their curriculum such that a student can complete some required graduate credit hours while completing the undergraduate degree. For instance, some of the graduate curriculum should also satisfy electives for the undergraduate major.

The program's Graduate Director will designate credit hours to be shared through the advising form and master's degree conferral review process. Shared credit hours will not be marked on the undergraduate record as having a special status in the undergraduate program. They will be included in the student's undergraduate earned hours and GPA. Graduate credit hours taken during the undergraduate program will not be included in the graduate GPA calculation.

- <sup>1</sup> If students wish to transfer credits from another university to Loyola University Chicago, the program's Graduate director will review the relevant syllabus(es) to determine whether it meets the criteria for a 400 level course or higher.
- <sup>2</sup> Programs with specialized accreditation requirements that allow programs to offer graduate curriculum to undergraduate students will conform to those specialized accreditation requirements.
- <sup>3</sup> In rare cases, the Graduate Director may authorize enrollment in a 400-level course for a highly qualified and highly motivated undergraduate, ensuring that the undergraduate's exceptional participation in the graduate class will not diminish in any way the experience of the graduate students regularly enrolled.
- <sup>4</sup> For example, if a particular course is only offered once every 2-3 years, and a student has demonstrated the necessary ability to be successful, the Graduate Director may allow a student to take a graduate level course to be shared prior to the student being formally admitted to the graduate program. See, also, footnote 3.
- <sup>5</sup> Students should not, for example, attempt to negotiate themselves out of a writing intensive requirement on the basis of admission to a graduate program.

## Graduation

Degrees are awarded sequentially. All details of undergraduate commencement are handled in the ordinary way as for all students in the

School/College/Institute. Once in the graduate program, students abide by the graduation deadlines set forth by the graduate program. Students in these programs must be continuously enrolled from undergraduate to graduate degree program unless given explicit permission by their program for a gap year or approved leave of absence.

## Learning Outcomes

### Learning Outcomes for the BS

Loyola University Chicago's major in Theoretical Physics / Applied Mathematics is an interdisciplinary program that provides extensive training in both physics and mathematics. It prepares students for graduate study in physics, mathematics, or applied mathematics; careers in fields such as engineering or computer science that value quantitative reasoning and mathematical modeling; or technical training in professions like medicine, dentistry, or law.

Students majoring in Theoretical Physics / Applied Mathematics possess a versatile set of skills that are well-suited to data science, numerical modeling, and quantitative analysis. They may pursue careers in higher education, at research institutes or government labs, or in high-tech industries. Recent majors have gone on to world class graduate programs in fields ranging from physics to neuroscience, and programming jobs at major tech companies.

The course of study for the Theoretical Physics / Applied Mathematics major covers the core classes in the Physics major, provides laboratory experience, and adds a comprehensive mathematics component. Upon completion of this program, students will:

1. Exhibit foundational knowledge in both physics and mathematics.
2. Be able to develop and interpret mathematical models that provide both quantitative and qualitative understanding of physical systems.
3. Possess intermediate level laboratory skills that will serve as a foundation for more advanced training in graduate or professional school.
4. Recognize how careful data collection and analysis helps develop or falsify scientific theories.
5. Demonstrate effective and ethical decision-making abilities in issues related to the sciences.

### Graduates of the Master of Science in Mathematics Program will:

- be able to construct mathematical proofs of basic theorems, and to write these proofs clearly using correct grammatical constructs and appropriate mathematical notation;
- have seen applications of mathematics to areas across mathematical disciplines and outside of mathematical disciplines;
- receive the training sufficient for acceptance into PhD programs or professional schools, or for hire in mathematics related industries;
- receive training on how to act responsibly and ethically within the discipline.