PHYSICS, BS

Physics is the study of matter and energy and their interactions, both in nature and under man-made conditions. Physics provides both the fundamental foundation for science and technology, and the framework for understanding the world around us and the universe itself.

UWM students can shape their Physics major in one of two directions. The standard major provides a broad overview of all aspects of physics: mechanics, optics, thermodynamics, quantum physics, magnetism, electricity, and the mathematical principles that underlie physics. In the astronomy focused version of the major, students master these basics plus take additional coursework in astrophysics and gravitation.

UWM's program provides excellent preparation for graduate programs in physics, engineering, and math, and can also serve as a springboard to careers in diverse areas, including engineering, business, law, and medicine. All Physics undergraduates are encouraged to get involved in research as early as their freshman year as a means to enhance their education and help diversify their career options.

Course of Study – Bachelor of Science Degree

Complete 120 credits including 75 credits in the College of Letters & Science and with 36 of the 75 credits in L&S upper-level (numbered above 300) courses and 30 of those 36 credits in designated L&S Advanced Natural Science courses (https://catalog.uwm.edu/letters-science/approved-courses-advanced-natural-science/).

The College requires that students complete in residence at UWM at least 15 credits in upper-division (numbered 300 or above) courses in their major. The College also requires that students complete at least 30 credits overall in residence at UWM. For additional residency and transfer credit limitations, see L&S Undergraduate Policies and Regulations (https://catalog.uwm.edu/letters-science/#policiesandregulationstext).

Students are also required to complete University-wide General Education Requirements (https://catalog.uwm.edu/policies/undergraduate-policies/#bachelorsdegreegeneraleducation) and the specific L&S requirements listed below.

To complete a major, students must satisfy all the requirements of the major as stated in this catalog. Students who declare their majors within five years of entering the UW System as a degree candidate may satisfy the requirements outlined in any catalog issued since the time they entered. Credits used to satisfy the major also may be used to satisfy other degree requirements.

University General Education Requirements (GER)

Code	Title	Credits
Oral and Written Communication		
Part A		
Achieve a grade of C or better in the following course:		
ENGLISH 102	College Writing and Research (or equivalent)	
Part B		
Course designated as OWC-B; may be completed through a major-specific course requirement		
Quantitative Literacy		
Part A		
Earn at least 3 credits with a grade of C or higher in one of the following courses or an equivalent course, or achieve a placement code of at least 30 on the mathematics placement test (or other appropriate test, as determined by the Mathematical Sciences Department)		
MATH 102	Mathematical Literacy for College Students II	
MATH 103	Contemporary Applications of Mathematics	
MATH 105	Introduction to College Algebra	
MATH 108	Algebraic Literacy II	
MATH 111	Introduction to Logic - Critical Reasoning [1]	
or PHILOS 111	Introduction to Logic - Critical Reasoning	
MATH 116	College Algebra	
Or equivalent course		
Part B		
Course designated as QL-B; may be completed through a major-specific course requirement		
Arts		
Select 3 credits		3
Humanities		
Select 6 credits		6
Social Sciences		
Select 6 credits		6
Natural Sciences		
Select 6 credits (at least two courses including one lab)		6
UWM Foreign Language Requirement		
Complete Foreign Language Requirement through:		
Two years (high school) of a single foreign language		
Two semesters (college) of a single foreign language		
Or equivalent		
UWM Cultural Diversity Requirement		
One course from the Arts, Humanities, or Social Sciences must also satisfy UWM's Cultural Diversity requirement		

[1] Math 111 and Philosophy 111 are jointly offered and count as repeats of one another. Students cannot receive credit for both courses.

College of Letters & Science Requirements

The degree requirements in the College of Letters and Science build on the University General Education Requirements to provide a broad base of knowledge as well as an array of skills cited by employers as critical to professional success: critical thinking, problem solving, oral and written communication, ability to work well with others, and adaptability to change.

For the Bachelor of Science (B.S.), you must complete the UWM General Education Requirements as well as these L&S requirements: the International requirement, the Breadth requirement, and the Research requirement. The International requirement develops your potential for cross-cultural understanding in a globalizing world. The Breadth requirement ensures that you take classes in a wide variety of subjects, across humanities, natural sciences, and social sciences. The Research requirement calls for you to build your critical thinking and oral and

written communication skills through conducting an independent research project, usually in your major.

For the Bachelor of Science (B.S.) you will complete additional coursework in L&S Advanced Natural Science courses (https://catalog.uwm.edu/letters-science/approved-courses-advanced-natural-science/).

I. Total Credits and Upper-Division Courses Requirement

Students must complete 120 credits including 75 credits in the College of Letters & Science and with 36 of the 75 credits in L&S upper-level (numbered above 300) courses.

II. L&S Advanced Natural Sciences Requirement

For the Bachelor of Science, students must complete 30 credits of the 36 credits in upper-division courses in designated L&S Advanced Natural Science courses (https://catalog.uwm.edu/letters-science/approved-courses-advanced-natural-science/).

III. International Requirement

To meet the International Requirement, students must successfully complete some three course (minimum 9 credits) combination of

1. language other than English (*not* including American Sign Language) at 3rd semester level or above, ***and/or***
2. non-language courses with L&S approved international content (see Courses Approved for the L&S International Requirement (https://catalog.uwm.edu/letters-science/approved-courses-international-requirement/) for course options).

IV. Breadth Requirement

In addition to completing the University General Education Requirements, L&S students must complete the Breadth requirement.

The L&S Breadth requirement calls for 6 credits each in L&S courses designated L&S Humanities, L&S Natural Sciences, and L&S Social Sciences breadth. One of the L&S Natural Science breadth courses must be a laboratory or fieldwork course. These courses must be beyond and in addition to courses in those areas used to satisfy General Education Requirements.

Please refer to the list of Courses Approved for the L&S Breadth Requirement (https://catalog.uwm.edu/letters-science/breadth-requirement-course-list/).

V. The Major

The College requires that students attain at least a 2.0 GPA in all credits in the major attempted at UWM. In addition, students must attain a 2.0 GPA on all major credits attempted, including any transfer work. Individual departments or programs may require higher GPAs for graduation. Some departmental majors require courses from other departments. Contact your major department for information on whether those credits will count as part of the major GPA. The College requires that students must complete in residence at UWM at least 15 credits in upper-division (numbered 300 or above) courses in their major.

Research Requirement

Within their majors, students must complete a research experience approved by the L&S faculty. A list of courses satisfying the research requirement in each major can be found here (https://catalog.uwm.edu/letters-science/approved-courses-research-requirement/).

VI. The Minor

Students are encouraged to consider completing a minor, but it is not required. To complete a minor, the College of Letters and Science requires that students attain at least a 2.0 GPA in all credits in the minor attempted at UWM. In addition, students must attain a 2.0 GPA on all minor credits attempted, including any transfer work. The minor must contain at least 9 credits in upper-division (numbered 300 and above) courses.

Physics Major Requirements

The department offers two study options. The **standard physics major** is for students who seek a general physics degree. The **physics major with astronomy emphasis** is for students who wish to pursue their interest in astronomy. While the standard physics major generally is followed by students who plan to go on to graduate school, the major with astronomy emphasis also enables students to pursue graduate work in physics.

Both options require that students take at least 15 credits in the major in advanced-level (numbered 300 and above) courses in residence at UWM. The College of Letters & Science requires that students attain at least a 2.0 GPA on all credits in the major attempted at UWM. In addition, students must attain a 2.0 GPA on all major credits attempted, including any transfer work. All students in the College are required to complete a research experience in their majors. Physics majors meet this requirement by successfully completing an upper-level, 3-credit laboratory courses.

Freshmen who enter with scores of 4 or 5 on the Physics Advanced Placement exam given by CEEB are given partial credit for the introductory courses.

Standard Physics Major

A minimum of 43 credits in physics, including:

Code	Title	Credits
Select one of the following options: [1]		10
Option 1:		
PHYSICS 209 & PHYSICS 214	Physics I (Calculus Treatment) and Lab Physics I (Calculus Treatment)	
PHYSICS 210 & PHYSICS 215	Physics II (Calculus Treatment) and Lab Physics II (Calculus Treatment)	
Option 2:		
PHYSICS 219	Physics I: Calculus-Based, Studio Format	
PHYSICS 220	Physics II: Calculus-Based, Studio Format	
PHYSICS 309	Physics III: Modern Physics	3
PHYSICS 317	Thermodynamics	3
PHYSICS 325	Optics	4
PHYSICS 370	Analytical and Numerical Methods in Physics	3
Select one of the following: [2]		3
PHYSICS 406	Introduction to Infrared Microspectroscopy	
PHYSICS 407	Computational Physics Laboratory	
PHYSICS 408	Experiments in Linear Electronics	
PHYSICS 409	Modern Physics Laboratory	
PHYSICS 670	Electron Microscopy Laboratory	
PHYSICS 391	Undergraduate Research Participation [3]	
PHYSICS 411	Mechanics	4
PHYSICS 420	Electricity and Magnetism I	3

PHYSICS 422	Electricity and Magnetism II	3
PHYSICS 441	Introduction to Quantum Mechanics I	4
PHYSICS 442	Introduction to Quantum Mechanics II	3
Electives		
Selecting electives are encouraged (see below)		
Total Credits		**43**

1 PHYSICS 209/PHYSICS 214 and PHYSICS 210/PHYSICS 215 are strongly recommended; however, PHYSICS 219 and PHYSICS 220 may be substituted.

2 These courses are **not** offered every semester; check with the undergraduate advisor to plan for completing this requirement.

3 The research proposal must be approved by the undergraduate advisor and the Departmental Undergraduate Committee, and it must demonstrate pedagogical value. Unfocused laboratory internships are not acceptable.

Electives

No elective courses are required, but students are encouraged to select electives from Physics or Astronomy courses 300 level or above from the following list. Only the courses identified in the list below with the phrase "if not selected above" will be counted in the student's major GPA. Electives may not be offered every semester; check with the undergraduate advisor to plan for completing this requirement.

Code	Title	Credits
ASTRON 400	Astrophysics I	3
ASTRON 401	Astrophysics II	3
PHYSICS 305	Medical Physics	3
PHYSICS 306	Introduction to Biophysics	3
PHYSICS 351	Basics of Condensed Matter Physics	3
PHYSICS 391	Undergraduate Research Participation	1-6
PHYSICS 406	Introduction to Infrared Microspectroscopy (if not selected above)	3
PHYSICS 407	Computational Physics Laboratory (if not selected above)	3
PHYSICS 408	Experiments in Linear Electronics (if not selected above)	3
PHYSICS 409	Modern Physics Laboratory (if not selected above)	3
PHYSICS 501	Special Topics: Mathematical Models of Physical Problems I	3
PHYSICS 515	Statistical Mechanics	3
PHYSICS 517	Special Relativity	3
PHYSICS 531	Principles of Quantum Mechanics I	3
PHYSICS 532	Principles of Quantum Mechanics II	3
PHYSICS 541	Elementary Particles	3
PHYSICS 551	Introduction to Solid State Physics I	3
PHYSICS 651	Introduction to Solid State Physics II	3
PHYSICS 670	Electron Microscopy Laboratory (if not selected above)	3

Physics Major with Astronomy Emphasis

A minimum of 55 credits in physics and astronomy courses, including:

Code	Title	Credits
Required		
Select one of the following options: [1]		10
Option 1:		
PHYSICS 209 & PHYSICS 214	Physics I (Calculus Treatment) and Lab Physics I (Calculus Treatment)	
PHYSICS 210 & PHYSICS 215	Physics II (Calculus Treatment) and Lab Physics II (Calculus Treatment)	
Option 2:		
PHYSICS 219	Physics I: Calculus-Based, Studio Format	
PHYSICS 220	Physics II: Calculus-Based, Studio Format	
PHYSICS 309	Physics III: Modern Physics	3
PHYSICS 325	Optics	4
PHYSICS 317	Thermodynamics	3
PHYSICS 370	Analytical and Numerical Methods in Physics	3
Select one of the following: [2]		3
PHYSICS 406	Introduction to Infrared Microspectroscopy	
PHYSICS 407	Computational Physics Laboratory	
PHYSICS 408	Experiments in Linear Electronics	
PHYSICS 409	Modern Physics Laboratory	
PHYSICS 670	Electron Microscopy Laboratory	
PHYSICS 391	Undergraduate Research Participation [3]	
PHYSICS 411	Mechanics	4
PHYSICS 420	Electricity and Magnetism I	3
PHYSICS 422	Electricity and Magnetism II	3
PHYSICS 441	Introduction to Quantum Mechanics I	4
PHYSICS 442	Introduction to Quantum Mechanics II	3
ASTRON 400	Astrophysics I [2]	3
ASTRON 401	Astrophysics II [2]	3
Electives [2]		
Select 6 credits from the following:		6
ASTRON 103	Survey of Astronomy	
or ASTRON 211	Principles of Astronomy	
ASTRON 175	Cosmic Origins	
ATM SCI 110	The Origin, Composition, and Structure of the Planetary Atmospheres	
GEO SCI 120	Geology of the Planets	
PHYSICS 391	Undergraduate Research Participation	
PHYSICS 501	Special Topics: Mathematical Models of Physical Problems I	
PHYSICS 517	Special Relativity	
PHYSICS 541	Elementary Particles	
Or another course approved by the undergraduate advisor		
Total Credits		**55**

1 PHYSICS 209/PHYSICS 214 and PHYSICS 210/PHYSICS 215 are strongly recommended; however, PHYSICS 219 and PHYSICS 220 may be substituted.

2 These courses are **not** offered every semester; check with the undergraduate advisor to plan for completing this requirement.

[3] The research proposal must be approved by the undergraduate advisor and the Departmental Undergraduate Committee, and it must demonstrate pedagogical value. Unfocused laboratory internships are not acceptable.

Possible Course Substitutions for Students with Physics and Engineering Double Majors

One of the following courses may be substituted for PHYSICS 370:

Code	Title	Credits
CIV ENG 280	Computer Based Engineering Analysis	3
COMPSCI 240	Introduction to Engineering Programming	3
COMPSCI 250	Introductory Computer Programming	4
MECHENG 101	Computational Tools for Engineers	2

The following course may be substituted for PHYSICS 317:

Code	Title	Credits
MECHENG 301	Basic Engineering Thermodynamics	3

The combination of both of the following may substitute for PHYSICS 411:

Code	Title	Credits
CIV ENG 201	Statics	3
CIV ENG 202	Dynamics	3

Upper level engineering technical electives may be substituted for PHYSICS 325 and independent study/research may be substituted for the 400-level laboratory courses.

Plan of Study

A typical plan of study is as follows:

Year 1		
Fall		**Credits**
PHYSICS 209	Physics I (Calculus Treatment)	4
PHYSICS 214	Lab Physics I (Calculus Treatment)	1
	Credits	**5**
Spring		
PHYSICS 210	Physics II (Calculus Treatment)	4
PHYSICS 215	Lab Physics II (Calculus Treatment)	1
	Credits	**5**
Year 2		
Fall		
PHYSICS 309	Physics III: Modern Physics	3
PHYSICS 370	Analytical and Numerical Methods in Physics [1]	3
	Credits	**6**
Spring		
PHYSICS 317	Thermodynamics [2]	3
PHYSICS 325	Optics [2]	4
MATH 325	Vector Analysis [2]	3
PHYSICS 411	Mechanics [2]	4
	Credits	**14**
Year 3		
Fall		
PHYSICS 420	Electricity and Magnetism I [1]	3
PHYSICS 441	Introduction to Quantum Mechanics I [1]	4
Physics Lab (see table below)		3
	Credits	**10**
Spring		
PHYSICS 422	Electricity and Magnetism II [2]	3
PHYSICS 442	Introduction to Quantum Mechanics II [2]	3
	Credits	**6**
	Total Credits	**46**

Code	Title	Credits
Physics Lab		
Students should select one lab in consultation with their Physics & Astronomy advisor:		
PHYSICS 407	Computational Physics Laboratory [2]	3
PHYSICS 408	Experiments in Linear Electronics [1]	3
PHYSICS 409	Modern Physics Laboratory [2]	3
PHYSICS 391	Undergraduate Research Participation	1-6

Code	Title	Credits
For Astronomy Emphasis:		
ASTRON 400	Astrophysics I [3,5]	3
ASTRON 401	Astrophysics II [4,5]	3

[1] This course is only offered in Fall.
[2] This course is only offered in Spring.
[3] This course is only offered in Fall every other year.
[4] This course is only offered in Spring every other year.
[5] These courses are not required for the standard Physics major.

Physics BS Learning Outcomes

Students graduating from the Physics program will be able to:

- solve problems using the principles of classical mechanics, electrodynamics, thermodynamics, and quantum mechanics.
- employ general principles of physics to develop mathematical models of the physical world.
- apply appropriate mathematical and numerical techniques, including approximate methods.
- critically evaluate the validity of the results.
- design and conduct scientific experiments to test new ideas and theories using standard laboratory procedures.
- analyze the data using basic statistical principles.
- present concepts and results clearly, in both written and oral form, to peers and the public.

Letters & Science Advising

During your time at UWM, you may have multiple members of your success team, including advisors, peer mentors and success coaches. Letters & Science students typically work with at least two different types of advisors as they pursue their degrees: professional college advisors and faculty advisors. L&S college advisors advise across your entire degree program while departmental faculty advisors focus on the major.

College advisors are located in Holton Hall (or virtually for online students) and serve as your primary advisor. They are your point person for your questions about navigating college and completing your degree. College advisors will:

- Assist you in defining your academic and life goals.
- Help you create an educational plan that is consistent with those goals.
- Assist you in understanding curriculum, major and degree requirements for graduation, as well as university policies and procedures.
- Provide you with information about campus and community resources and refer you to those resources as appropriate.
- Monitor your progress toward graduation and completion of requirements.

Faculty advisors mentor students in the major and assist them in maximizing their development in the program. You will begin working with a faculty advisor when you declare your major. Faculty advisors are an important partner and will:

- Help you understand major requirements and course offerings in the department.
- Explain opportunities for internships and undergraduate research and guide you in obtaining those experiences.
- Serve as an excellent resource as you consider potential graduate programs and career paths in your field.

Students are encouraged to meet with both their college advisor and faculty advisor at least once each semester. Appointments are available in-person, by phone or by video.

Currently enrolled students should use the Navigate360 website (https://uwm.navigate.eab.com/) to make an appointment with your assigned advisor or call (414) 229-4654 if you do not currently have an assigned Letters & Science advisor. Prospective students who haven't enrolled in classes yet should call (414) 229-7711 or email let-sci@uwm.edu.

Accelerated Program Option

This program is offered as part of an accelerated graduate program. For more information, see Accelerated Graduate Degrees (https://catalog.uwm.edu/opportunities-resources/accelerated-graduate-degrees/).

College of Letters and Science Dean's Honor List

GPA of 3.750 or above, earned on a full-time student's GPA on 12 or more graded credits in a given semester.

Honors College Degree and Honors College Degree with Distinction

Granted to graduating seniors who complete Honors College requirements, as listed in the Honors College (https://catalog.uwm.edu/honors-college/) section of this site.

Commencement Honors

Students with a cumulative GPA of 3.500 or above, based on a minimum of 40 graded UWM credits earned prior to the final semester, will receive all-university commencement honors and be awarded the traditional gold cord at the December or May Honors Convocation. Please note that for honors calculation, the GPA is **not** rounded and is truncated at the third decimal (e.g., 3.499).

Final Honors

Earned on a minimum of 60 graded UWM credits: Cum Laude - 3.500 or above; Magna Cum Laude - 3.650 or above; Summa Cum Laude - 3.800 or above.