Handbook for Current and Prospective Physics Majors

August, 2022

Department of Physics
University of Massachusetts Amherst

Contact List

Physics Department web page	*www.physics.umass.edu*
Physics Department main office	Lederle 1126, (413) 545-2545
Physics Department Hasbrouck office	Hasbrouck 411, (413) 545-2407
Department Head	Prof. Tony Dinsmore, LGRT 1126 *head@physics.umass.ed*u
Undergraduate Program Director	Prof. Donald Candela, PSB W112 *upd@physics.umass.edu* *(Primary contact for adding the major or minor)*
Honors Coordinator	Prof. Andrea Pocar *pocar@umass.edu*
Honors College web page	*https://www.umass.edu/honors/*
Honors College main office	157 Commonwealth Ave. (413) 545-2483

This Handbook is available at http://www.physics.umass.edu/undergraduate

Contents

Advising and Counseling Resources

Physics Department academic advisors meet with every physics major at least once every semester. Students are required to meet with an advisor prior to enrolling in the next semester's classes. At other times, if questions arise about classes, careers, summer jobs or internships, research opportunities, personal stresses, or any other aspect of UMass life, please contact your advisor.

If you are….

- not currently a physics major but want to learn more about it, please contact the Chief Undergraduate Advisor.
- already a physics major (as a primary major), then one of these advisors should have been assigned to you on SPIRE. If not, please contact the appropriate advisor or the Chief Undergraduate Advisor
- a second major in physics (SM-PHYS), then you might not have a physics advisor appointed on SPIRE. However, we still recommend that you visit a physics advisor each semester. Please contact the appropriate advisor from the list below. If you are not in the standard course sequence, then contact the Chief Undergraduate advisor instead.

Who we are:

SPIRE should show who your faculty advisor is (lower right of your student page). Othewise…

- Chief Undergraduate Advisor: Prof. Donald Candela, PSB W112, *upd@physics.umass.edu*
- Associate UPD: Dr. Shubha Tewari, Hasbrouck 301, *tewari@physics.umass.edu*
- Class of 2022:
  Prof. Don Candela, PSB W112, *candela@physics.umass.edu*
  Prof. Ben Brau, LGRT 1042, *bbrau@physics.umass.edu*
- Class of 2023:
  Prof. Rory Miskimen, PSB W112, *miskimen@physics.umass.edu*
  Prof. Jun Yan, LGRT 1042, *yan1@umass.edu*
- Class of 2024:
  Students with last names A-K: Prof. Benny Davidovitch, *bdavidov@physics.umass.edu*
  Students with last names L-Z: Prof. Verena Martinez Outschoorn, *vimartin@umass.edu*
- Class of 2025:
  Students with last names A-K: Prof. Guy Blaylock, *blaylock@physics.umass.edu*
  Students with last names L-Z: Prof. Stephane Willocq, *willocq@umass.edu*
- Class of 2026:
  Students with last names A-K: Prof. David Kawall, *kawall@physics.umass.edu*
  Students with last names L-Z: Prof. Lorenzo Sorbo, *sorbo@umass.edu*

Honors coordinator: Prof. Andrea Pocar, PSB W110, *pocar@physics.umass.edu*

Other resources:

The College of Natural Sciences advising center. They can advise on GenEd and language requirements, courses added or dropped after the initial Add/Drop period, or a 'credit overload' (>19). They also offer career advice (in addition to your advisor). (413) 545-1969, 220 Morrill II, *https://www.cns.umass.edu/advising*

You can also find GenEd info here: https://www.umass.edu/gened/students/fulfilling-requirements

Where to go when you are in distress:

- Dean of Students Office (DOSO).
  (413) 545-2684. Office: 227 Whitmore. *https://www.umass.edu/dean_students/*
  DOSO is a resource for you – not just a disciplinary office! Do not hesitate to call them if you need help with personal, medical and other emergencies. Thy can communicate with your instructors, help with medical exceptions to academic rules, etc. They can also refer you to other resources.
- The Center for Counseling and Psychological Health (CCPH), (413) 545-2337. CCPH is a go-to resource for students who struggle with anxiety, depression or any other kind of emotional stress. They are on-call 24/7. They can handle emergency and non-emergency/evaluation/advisory meetings. Calling them will not trigger a major response or commit a student to treatment.

Other Links and Contacts

SPS Society of Physics Students – An association for all students interested in physics. The group meets weekly, usually Mon or Wed evenings at 7pm in LGRT 1033, with pizza. Each year, SPS members elect their President, Vice President, and Treasurer. For information , please email *univmasssps@gmail.com* or *https://umassamherst.campuslabs.com/engage/organization/sps* or their Facebook page, *https://www.facebook.com/groups/UMassSPS/*

INTRODUCTION to Physics

Physics is the basic science that underlies all of the physical sciences and influences most of the biological sciences. Physics treats matter, energy, and interactions at the fundamental level. It is a perpetually changing science, with interdisciplinary aspects that shift as technology and study bring new fields and new possibilities to light. After physicists establish the fundamental principles within a field, the field is often "handed over" to another discipline for further exploration. Thus, much of the physics of yesterday is now regarded as part of chemistry or engineering.

Physics provides an excellent background for *a variety* of careers in science, technology, teaching, and beyond. Physicists entering research generally need to choose among multiple possible branches. Physicists can work in either basic or applied research. The scientist engaged in the former typically works in a university or a national laboratory, delving into the fundamental processes of nature. Applied research concerns itself with applications of our knowledge by way of technological advances, in an industrial or commercial setting. There is also a choice between working in theory or experiment. Experimentalists create and use a given apparatus to test hypotheses and theories, to make unexpected discoveries of new phenomena, or to develop new applications of ideas. Theorists either use that data, or operate independently of data, to develop new explanations, hypotheses, or theories. Particularly broad scientists can act as both, often using computer simulations to gain insight into both the theoretical and experimental aspects of a given problem. Research physicists choose to work in some specific area, such as nuclear, condensed matter, or high-energy particle physics.

The Department of Physics offers a variety of courses and a variety of possibilities for majors. Since physics is an ever-changing field, the focus of the department is to impart a set of skills that can be applied over a wide range of disciplines. The Applied and General Tracks for majors

exist to address the needs of students moving into the job market, or graduate school in another field, after graduation. The Professional Track exists for those students who plan on post-bachelor's education in physics or closely related fields, or for those students who want to pursue a rigorous BS degree in physics.

You can also join our faculty in research (see p. 17). Most faculty members are engaged in basic experimental or theoretical research in the following areas: biophysics, hard and soft condensed-matter physics, experimental and theoretical particle physics, experimental and theoretical gravity, low-temperature physics, nano-science, nuclear physics, and polymer research. Excellent facilities and federal research funds make undergraduate research opportunities widely available through independent study, honors research, or summer employment.

University and College Requirements

To receive a bachelor's degree in physics a student must meet graduation requirements set by (i) the University, (ii) the College of Natural Sciences, and (iii) the Physics Department. The University requirements (total number of credits, number of credits in residence, GPA, general education requirements) are explained elsewhere, *e.g.*, on SPIRE. Here is a concise list of GenEd requirements: https://www.umass.edu/gened/students/fulfilling-requirements.

Physics Department Requirements

The Physics Department offers three different degree tracks for study. These degree tracks are the *Professional*, the *Applied*, and the *General* tracks. You can find a concise checklist for each one at the end of this handbook.

A minimum GPA of 2.0 is required for courses counted toward the Physics major for all three degree tracks.

Physics Curriculum: Professional Track

The Professional Track provides a broad background in physics. It is intended for majors who want a rigorous and traditional physics curriculum. P-track majors might take on jobs after graduation or go to graduate school. This track requires no outside concentration in another field. This option results in the earning of a Bachelor of Science (B.S.) degree. **To see how these would work in the 4 years and for other recommendations, see the checklist near the end of this handbook**.

1. Introductory Sequence

Fall

PHYSICS 181 Physics I – Mechanics + Lab	4 credits
PHYSICS 185 Freshman Colloquium	1 credit
PHYSICS 192M Intro to Measurement using Arduino (recommended)	1 credit
(and math, see below)	

Spring

PHYSICS 182 Physics II – Electricity and Magnetism + Lab	4 credits
PHYSICS 192M Introduction to Measurement using the Arduino	1 credit
(and math, see below)	

In special circumstances, your advisor can authorize an alternate introductory sequence.

2. Sophomore Sequence

Fall

PHYSICS 281 Computational Physics 3 credits PHYSICS 287 Physics III - Thermodynamics, Waves, Optics 3 credits PHYSICS 289 Physics III Lab 1 credit

Spring

PHYSICS 282 Techniques of Theoretical Physics 3 credits PHYSICS 284 Modern Physics I 3 credits PHYSICS 286 Modern Physics Lab 2 credits

3. Intermediate Series

PHYSICS 440 Intermediate Lab (Fall or Spring) 4 credits
PHYSICS 421 Mechanics (Fall) 4 credits PHYSICS 422 Intermediate Electricity & Magnetism (Spring) 4 credits PHYSICS 423 Statistical Physics & Thermodynamics (Spring) 4 credits PHYSICS 424 Quantum Mechanics (Fall) 4 credits

4. Writing Requirement

PHYSICS 381 Writing in Physics (F or S) 3 credits

Students with double majors should take the writing course offered by their primary major department

5. Advanced Courses and Labs

One advanced course must be selected from the following Some of the courses listed here are not offered every year. Typically, these classes are held based on student interest and pre-enrollment. Students should contact an advisor for information on planned course offerings.

PHYSICS 531 Electronics for Scientists I	(Fall)	4 credits
PHYSICS 551 Biological Physics	(Spring)	3 credits
PHYSICS 553 Optics with Lab	(Spring)	4 credits
PHYSICS 556 Nuclei and Elementary Particles	(Spring)	3 credits
PHYSICS 558 Solid State Physics	(Spring)	3 credits
PHYSICS 562 Advanced Electricity and Magnetism	(Fall)	3 credits
PHYSICS 564 Advanced Introductory QM	(Fall)	3 credits
PHYSICS 568 General Relativity	(Fall)	3 credits
PHYSICS 597Q Quantum Computation	(Fall)	3 credits
ASTRON 337 Optical and Infrared Astronomy		4 credits
ASTRON 338 Techniques of Radio Astronomy		4 credits
ASTRON 451 Astrophysics I		4 credits
ASTRON 452 Astrophysics II		4 credits

6. Math Requirements

MATH 131 Calculus I (co-requisite for P181) (Fall and Spring) 4 credits MATH 132 Calculus II (co-requisite for P182) (Fall and Spring) 4 credits MATH 233 Multivariate Calculus (Fall and Spring) 3 credits MATH 331 Ordinary Differential Equations (Fall and Spring) 3 credits

A course in linear algebra, Math 235, is also recommended.

Physics Curriculum: Applied Track

The Applied Track is intended for students with an specific interest in a technical subject that is not within the standard canon of physics. Applied track students might plan to enter the job market immediately after graduation, or may plan to attend graduate school in a topic outside physics. Although the Applied Track requires fewer physics courses than the Professional Track, this is balanced by the requirement of an 18-credit concentration in a coherent scientific or technical sub-field. This option results in a Bachelor of Science (B.S.) degree.

This track works well for students who have or develop a particular interest. It is not suitable for an all-around training in physics. (The P track is the better choice for that.) **To see how these would work in the 4 years and for other recommendations, see the checklist near the end of this handbook**.

1. Introductory Sequence

Fall

PHYSICS 181 Physics I – Mechanics + Lab 4 credits
PHYSICS 185 Freshman Colloquium 1 credit
(and math, see below)

Spring

PHYSICS 182 Physics II – Electricity and Magnetism + Lab 4 credits
PHYSICS 192M Intro to Measurement using Arduino (recommended) 1 credit
(and math, see below)

In special circumstances, your advisor can authorize an alternate introductory sequence.

2. Sophomore Sequence

Fall

PHYSICS 287 Thermodynamics, Waves, Optics 3 credits
PHYSICS 289 Thermodynamics, Waves, Optics Lab 1 credit
PHYSICS 281 Computational Physics 3 credits

Spring

PHYSICS 284 Modern Physics I 3 credits
PHYSICS 286 Modern Physics Lab 2 credits

Physics 282, Techniques of Theoretical Physics, is strongly recommended, as it is needed for the upper-level classes especially 422 and 424.

3. Intermediate Series

PHYSICS 440 Intermediate Lab (Fall or Spring) 4 credits

and students must also take at least <u>two</u> of the following:

PHYSICS 421 Intermediate Mechanics (Fall) 4 credits PHYSICS 422 Intermediate Electricity & Magnetism (Spring) 4 credits PHYSICS 423 Statistical Physics & Thermodynamics (Spring) 4 credits PHYSICS 424 Quantum Mechanics (Fall) 4 credits

4. Writing Requirement

PHYSICS 381 Writing in Physics (F or S) 3 credits

Students with double majors normally take the writing course offered by their primary major.

5. Advanced Courses and Labs

One advanced course must be selected from the following. Some of the courses listed here are not offered every year. Typically, these classes are held based on student interest and pre-enrollment. Students should contact their advisors for information on planned course offerings.

PHYSICS 531 Electronics for Scientists I	(Fall)	4 credits
PHYSICS 551 Biological Physics	(Spring)	3 credits
PHYSICS 553 Optics with Lab	(Spring)	4 credits
PHYSICS 556 Nuclei and Elementary Particles	(Spring)	3 credits
PHYSICS 558 Solid State Physics	(Spring)	3 credits
PHYSICS 562 Advanced Electricity and Magnetism	(Fall)	3 credits
PHYSICS 564 Advanced Introductory QM	(Fall)	3 credits
PHYSICS 568 General Relativity	(Fall)	3 credits
PHYSICS 597Q Quantum Computation	(Fall)	3 credits
ASTRON 337 Optical and Infrared Astronomy		4 credits
ASTRON 338 Techniques of Radio Astronomy		4 credits
ASTRON 451 Astrophysics I		4 credits
ASTRON 452 Astrophysics II		4 credits

6. Math Requirements

MATH 131 Calculus I (co-requisite for P181) (Fall and Spring) 4 credits MATH 132 Calculus II (co-requisite for P182) (Fall and Spring) 4 credits MATH 233 Multivariate Calculus (Fall and Spring) 3 credits

A course in linear algebra, Math 235, is also recommended.

7. Concentration in Technical Electives

For this requirement, the student must take a minimum of 18 credits with a specific scientific or technical focus. The purpose of the concentration is to develop coherent, expert competency in a scientific or technical subfield. Therefore, a broadly defined concentration such as "Astronomy" or "Computer Science" would not be suitable, nor would Gen-Ed or independent study courses. The student's advisor must approve the coursework for a given concentration, preferably within the sophomore or junior years. Sample concentrations will be found in the section "Sample Plans of Study". At the end of this Handbook, there is a one-page "Applied-Track Checklist". A student intending to follow the Applied Track should fill out this checklist with the courses intended to fulfill the 18-credit concentration requirement, and have the list approved by their academic advisor.

Physics Curriculum: General Track

The General Track allows a student to concentrate in a non-technical area, such as teaching or science writing. This option results in the earning of a Bachelor of Arts (B.A.) degree and requires foreign-language classes (see below). **To see how these would work in the 4 years and for other recommendations, see the checklist near the end of this handbook**.

1. Introductory Sequence

Fall

PHYSICS 181 Physics I – Mechanics + lab 4 credits
PHYSICS 185 Freshman Colloquium 1 credit
(and math, see below)

Spring

PHYSICS 182 Physics II – Electricity and Magnetism + lab 4 credits
PHYSICS 192M Intro to Measurement using Arduino (recommended) 1 credit
(and math, see below)

In special circumstances, your advisor can authorize an alternate introductory sequence.

2. Sophomore Sequence

Fall

PHYSICS 287 Thermodynamics, Waves, Optics 3 credits
PHYSICS 289 Thermodynamics, Waves, Optics Lab 1 credit
PHYSICS 281 Computational Physics 3 credits

Spring

PHYSICS 284 Modern Physics I 3 credits
PHYSICS 286 Modern Physics Lab 2 credits

Physics 282, Techniques of Theoretical Physics, is also recommended, as it is needed for the upper-level classes especially 422 and 424.

3. Intermediate Series

PHYSICS 440 Intermediate Lab (Fall or Spring) 4 credits

4. Writing Requirement

PHYSICS 381 Writing in Physics 3 credits

Students with double majors normally take the writing course offered by their primary major department.

5. Advanced Courses and Labs

One advanced course must be selected from the following. Some of the courses listed above are not offered every year. Typically, these classes are held based on student interest and pre-enrollment. Students should contact their advisors for information on planned course offerings.

PHYSICS 421 Intermediate Mechanics (Fall) 4 credits PHYSICS 422* Intermediate Electricity & Magnetism (Spring) 4 credits PHYSICS 423 Statistical Physics & Thermodynamics (Spring) 4 credits PHYSICS 424* Quantum Mechanics (Fall) 4 credits PHYSICS 531 Electronics for Scientists I (Fall) 4 credits PHYSICS 553 Optics with Lab (Spring) 4 credits *Students should take Phys282 before taking Phys422 or 424.

Other ourses listed under 'Advanced courses:' Consult your advisor.

6. Math Requirements

MATH 131 Calculus I (co-requisite for P181) (Fall and Spring) 4 credits MATH 132 Calculus II (co-requisite for P182) (Fall and Spring) 4 credits MATH 233 Multivariate Calculus (Fall and Spring) 3 credits

A math course in linear algebra, Math 235, is also recommended.

7. Concentration Electives

For this requirement, the student must take a minimum of 18 credits within a specific concentration. This need not be a technical area, and those seeking a focus in a technical area should consider the Applied Track instead. The student's advisor must approve the coursework for a given concentration, preferably within the sophomore or early junior years. Sample concentrations will be found in the section "Sample Four-Year Plans." At the end of this Handbook, there is a one-page "General-Track Checklist". A student intending to follow the General Track should fill out this checklist with the courses intended to fulfill the 18-credit concentration requirement, and have the list approved by their academic advisor.

8. College of Natural Science Requirements for the B.A. Degree

Students pursuing the B.A. degree must also satisfy the **foreign language requirement** in the College of Natural Science. For details go to:
http://www.cns.umass.edu/academics/cns-degree-requirements

Sample Plans of Study

The following plans of study give possible arrangements of courses by semester and year. Real schedules should be adjusted, of course, to suit each student's particular needs.

All freshmen, sophomore, and transfer physics majors take the same set of introductory courses. *Most physics courses are only offered once per year (Fall or Spring), plan your schedule accordingly!* The Freshman Colloquium, P185, is not a required course but it is recommended for all physics majors.

First Semester

Physics 181 Mechanics + Lab
Math 131 Calculus I (or higher)

Physics 185 Freshman Colloquium
ENGLWP 112 College Writing
Gen Ed Course

Second Semester

Physics 182 E&M + Lab
Math 132 Calculus II (or higher)
Physics 192M Intro2Measurement
Gen Ed Course(s)

Other courses of interest (*e.g.* computing, chemistry, biology, other math.

Third Semester

Physics 287 Thermo., optics and waves
Physics 289 Lab for P287

Physics 281 Computational Physics
331 Differential Equations†
Gen Ed Course

Fourth Semester

Physics 284 Modern Physics I
Physics 286 Lab for P284
Physics 282 Theoretical Techniques*

Math 233 Multivariate Calculus Math
Gen Ed Course

* Physics 282 is *not required* for the Applied and General tracks, but is strongly recommended.
† Math 331 is *not required* for the Applied and General tracks.

After this common introductory sequence, your plan of study will depend upon which track you choose (Professional, Applied, or General).

General Education requirements for students starting Fall 2018 and later:
For details and the official rules, see
https://www.umass.edu/gened/sites/default/files/cpg_admitted_students_f2018_rev.pdf

Physics students satisfy the PS GenEd requirement by taking Physics 181, and the R1/R2 requirement by taking Math 131. Physics students will in general need to take one BS GenEd and four Social World GenEd's including two diversity courses. The University Integrative Experience requirement is satisfied by taking Physics 440 Intermediate Lab in the third or fourth year.

Sample Plan of Study - Professional Track

Third Year

Fall	**Spring**
Physics 381 Writing in Physics	Physics 422 Electricity and Magnetism
Physics 421 Mechanics	Physics 423 Statistical Physics
Physics 424 Quantum Mechanics	Physics 440 Intermediate Lab
Math elective (235 is recommended)	

Fourth Year

Fall	**Spring**
500-Level Physics Course	Physics Electives
Physics Electives	Physics 496 Indep. Study/Research
Physics 496 Indep. Study/Research	

For students who want to apply to graduate school, this plan will prepare for the Physics GRE exam in the fall of the fourth year, and leaves the majority of the senior year available for honors thesis or special projects. Such students should also take **Physics 498G** (1 cr) in the spring of their junior year. Your physics advisor can recommend other options for the sequence of taking courses.

More options and more details are given in the checklist near the end of this document.

Sample Plan of Study - Applied Track

Third Year

Fall	Spring
Physics 381 Writing in Physics	Physics 422 or 423
Physics 421 or 424	500-Level Physics Course Math
elective (235 is recommended)	Physics 440 Intermediate Lab
Technical Option	Technical Option

Fourth Year

Fall	Spring
Physics Electives	Technical Options
Technical Options	

A wide variety of concentrations can be created within the Applied Track. As stated in the Applied Track requirements, the purpose of the concentration is to develop coherent, expert competency in a chosen scientific or technical subfield. Therefore, a broadly defined concentration such as "Astronomy" or "Computer Science" would not be suitable, nor would Gen-Ed introductory level, or independent study courses. The Applied Track is intended for students with a specific interest in a technical subject that is not within the standard canon of physics. This track is not intended as a mechanism for students in another major that requires physics courses to meet the requirements for a dual major.

The following are samples of concentrations for given fields. *In creating concentration programs, students should get advice from an advisor in the concentration program. Some classes may have limited availability non-major students (i.e. physics majors). For example, this can be a concern for Engineering or CICS colleges. In the past, however, physics students have not had a problem with this. The Physics UPD may be able to help if you need a course outside physics and find difficulty enrolling because of department rules.*

Sample Concentration in Mechanical Engineering

PHYSICS 423 Statistical Physics and Thermodynamics should be one of the two 400-level courses.

Physics 531 Electronics as an elective	4 credits
MIE 330 Thermodynamics II	3 credits
MIE 340 Fluid Mechanics I	3 credits
MIE 354 Heat Transfer	3 credits
MIE 440 Fluid Mechanics II	3 credits
MIE 570 Solar Energy Conversion	3 credits
MIE 573 Engineering of Wind Power Systems	3 credits

Note: PHYSICS 531 could be taken as a part of this technical elective rather than as one of the courses completing advanced physics lab requirements (see Applied Track requirements) otherwise the student would be short three credits for the technical elective (fifteen instead of the requisite eighteen).

Sample Concentration in Pre-Medicine

CHEM 111 General Chemistry for Science and Engineering Majors w/lab	4 credits
CHEM 112 General Chemistry for Science and Engineering Majors w/lab	4 credits
CHEM 261 Organic Chemistry I	3 credits
CHEM 262 Organic Chemistry II	3 credits
CHEM 290A Organic Lab	2 credits
BIOL 100 Introductory Biology I w/lab	4 credits
BIOL 101 Introductory Biology II w/lab	4 credits

Note: Although the 18-credit limit would be satisfied without taking all of these courses, it would be insufficient to satisfy the pre-medical requirements.

Sample Concentration in Biochemistry

BIOL 100 Introductory Biology I	4 credits
BIOL 101 Introductory Biology II	4 credits
CHEM 121 General Chemistry w/lab	4 credits
CHEM 122 General Chemistry w/lab	4 credits
BIOL 285 Cell and Molecular Biology	4 credits
BIOL 523 General Biochemistry	3 credits
BIOL 524 General Biochemistry	3 credits

Sample Plan of Study - General Track

Third Year

Fall	Spring
Physics 381 Writing in Physics	400 or 500 level physics course
Physics 440	Concentration Option
Concentration Option	

Fourth Year

Fall	Spring
Concentration Option	Concentration Option
Course in HFA or SBS	Course in HFA or SBS

The following are sample concentrations for given fields. *In creating concentration programs, students should get advice from an advisor in the concentration program. This is especially important for teacher certification.*

Sample Concentration in Science Writing

ENGL 379 Technical Writing	3 credits
ENGL 380 Professional Writing and Technical Communication I	3 credits
ENGL 381 Professional Writing and Technical Communication II	3 credits
ENGL 382 Professional Writing and Technical Communication III	3 credits
JOURN 300 News writing and Reporting	4 credits
JOURN 392M Introduction to Nonfiction Writing	4 credits

Sample Concentration in Teacher Education

EDUC 524 Work of the Middle and High School Teacher	3 credits
EDUC 592S Microteaching Lab	1 credit
EDUC 510 Teacher in the Middle and High School Classroom	2 credits
EDUC 534 Instructional Planning and Assessment	3 credits
EDUC 512 Teaching Science in the Middle and High School	3 credits
EDUC 500S Student Teaching	9 credits

Departmental Honors in Physics

Students who are members in good standing in the Honors College can participate in the Departmental Honors program in the Physics Department. The Physics Department requires,

i. two physics honors courses, with one course taken at any level, and the other course at the 300 level or higher. This requirement can be satisfied by taking a physics honors colloquium, or by enrolling in honors independent study associated with a physics course. These courses satisfy the two honors electives requirement of Honors College.
ii. an honors thesis or honors project completed under the supervision of a faculty advisor. The thesis or project satisfies the Honors College capstone experience requirement.
iii. all Honors College requirements are satisfied.

Many physics students find the prospect of doing a thesis in their declared major a more attractive option than taking one of the 6-credit capstone courses offered in the Honors College. *All honors students in the department are strongly encouraged to speak with the Department Honors Coordinator to discuss the possibility of declaring Departmental Honors.*
Students graduating with Departmental Honors in Physics have this academic distinction printed on their diplomas.

A check-list for doing departmental honors is attached near the end of this document.

Requirements for the Minor in Physics

Fifteen credits of courses in the Physics Department at the 200 level and above must be completed. The prerequisites to those courses must be satisfied, generally meaning:

- An introductory physics sequence (Physics 151-152, or 181-182)
- A math sequence including MATH 131, 132, and 233.
- No courses may be taken with a Pass/Fail option.
- Counting Independent Study courses toward the minor requires advisor approval in advance. In any case, not more than three credits of Independent Study will count toward the 15-credit requirement.
- [For the record, not relevant to current students: Only one of the two courses Physics 261, Physics 284 can be counted towards the 15-credit requirement.]

Departmental Support and Activities

Advising

Every student majoring in Physics has a faculty advisor within the department. (See page 3 of this document.) In the Physics Department, advisors are assigned to the students of a given class, so that physics majors have the same advisor from the time they enter the program until they graduate.

Normal counseling periods are during Fall and Spring pre-registration. Students should discuss their programs with their advisors at this time. *Students will not be cleared for registration until they meet with their faculty advisors.* Student should keep this in mind as the preregistration period approaches. Advisors, and the Undergraduate Program Director, are available at other times to provide academic guidance.

The advisors are responsible for guiding their students in the choice of courses and in the completion of Physics Major, College and University requirements. Students should use the SPIRE system to verify their progress towards meeting University, College, and Departmental requirements.

At the end of this handbook, there are one-page checklists for the three Physics degree tracks (Professional, Applied, and General). During the first advising visit with your academic advisor, any applicable courses you have taken will be marked on the checklist, and the list placed in your academic file. The checklist is updated every semester during advising visits. It is particularly important that students intending to follow the Applied or General tracks have their 18-credit area concentrations approved by their advisors before the senior year, preferably before the junior year.

Independent Study

Physics students may occasionally wish to concentrate on topics of their choice outside of the structured setting of traditional lecture classes. Opportunities for this sort of investigation exist by way of Independent Study courses. These courses are arranged privately, on a semester basis, between an individual student and a professor. Depending on the course load involved, these classes generally range from 1 to 3 credits. These courses are listed in the *Undergraduate Catalog* under the numbers 196, 296, 396, 496, and 596, corresponding to all of the possible undergraduate levels.

Arrangements for Independent Study should be carried out **between the student and the instructing professor** at some stage during the semester prior to the planned investigation. The Undergraduate Program Director must then approve enrollment in the course.

Undergraduate Research

Engaging in cutting-edge research is a valuable experience that can help you decide what you want to do for your career and likely enhance your excitement about studying physics. Research provides valuable training that complements your coursework and is an important component of your resume if you apply for graduate school or technical jobs.

In general, research opportunities can be found here on campus, or at non-profit institutions, government-run national labs, private companies, or other universities. There are a great many programs because so many institutions value the opportunity to train and recruit students like you. Research positions are generally paid, last for a summer (9-10 weeks), and sometimes are continued the following summer. Sometimes internships at companies or national labs lead to job offers. Internships can be taken by undergraduate students or graduate students.

A summary is below. For more information: https://www.physics.umass.edu/undergraduate

Internships are most often in research or development but they could also be in teaching or other areas. If you are looking for teaching opportunities, then you can find more information from Brokk Toggerson (who teaches a class on teaching physics, Phys390T), or the UMass School of Education, or the Amherst Regional Public Schools or other local public school systems.

Here at UMass, joining an on-campus research group in physics is very common. (The graduating class of 2016 reported that 70% of students had a research experience here on campus.) The Physics department has approximately 30 faculty and most of them engage in original research. Most of the faculty work with undergraduate students either part-time during the semester or full-time during the summer (or both). During the semester, research experience

is most commonly arranged as an Independent Study course (Physics 196, 296, 396 or 496) for academic credit. Sometimes these projects are full-time during the summer for pay. These experience are effectively internships, even though we do not always refer to them as such.

The Commonwealth Honors College Capstone Experience (essentially a senior thesis) is one excellent way to gain research experience. (Participation in research, however, is **not limited** to Commonwealth College students.) Commonwealth Honors College also provides funds for undergraduate research on a competitive basis. The Department also offers the Edward S. Chang and Kenneth Langley endowed funds to support summer research. Proposals are due annually in February.

Finding on-campus research opportunities is not difficult, but it is quite different from signing up for courses. The main difference is that you have to take the initiative in reaching out to professors. Here is what we recommend:

1) Take Physics 185 to get an overview of research and to see some details about some of the faculty. Also look at the department's web page and follow the research link. You will see a fairly brief (but vague) listing of faculty by the broad areas of research. You can also look at other departments; physics students have worked in Chemistry, Polymer Science and Engineering, and various departments in our Engineering college.
2) When you find something that looks interesting (even if don't know much about it and don't know if you are qualified!), then send an email to the professor. In your email, express an interest in the general topic of research, summarize courses you have taken (if any), and ask for a time to meet in person so that you (the student) can learn more about the science. Feel free to send more than one such letter in parallel. If you don't receive a reply, then write again a few days later and/or stop by the professor's office.
3) After you meet with the professor and talk about the science, then decide if you want to ask for an independent study and/or summer job. Go ahead and ask. Many groups work with first-semester freshmen, so don't second-guess your experience level. Again, you can ask more than one professor and then choose if you receive multiple offers. No one will feel insulted if you turn down an offer.
4) To sign up for an independent study (if this is the mechanism you and your research advisor choose), first make a plan with your research advisor, who will then help you arrange it with the Undergraduate Program Director.

Society of Physics Students and Sigma Pi Sigma

The Society of Physics Students (SPS) is a national organization for undergraduates interested in studies connected to physics. The Department of Physics has a local chapter, which participates in the regional activities of the national organization. Our chapter sponsors and assists student- led research groups, engages in outreach projects to local schools, sponsors informational evenings on subjects such as careers and summer internships, and holds social activities for its members.

All majors are invited to become members of the organization. Membership in the national organization is not mandatory, though information on how to become a national member is available from the officers of the local chapter. For more information on SPS see the contact list near the front of this Handbook.

Sigma Pi Sigma, an adjunct to the Society of Physics Students, is a national honors society for physics majors. Information on how to become a member is available from the faculty advisor of the SPS.

Exchange Programs

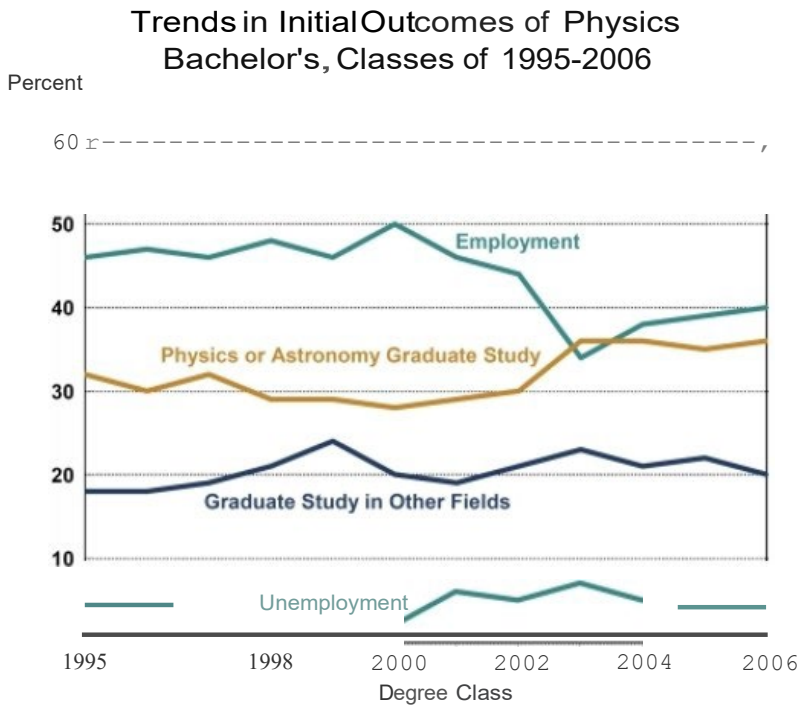
Undergraduates in Physics may wish to pursue a portion of their studies while in residence at another institution. Arrangements for this opportunity should be made through the appropriate exchange program at the University. The International Programs Office, *www.umass.edu/ipo/*, is the center for information about study abroad. The Domestic Exchange Program, *http://ualc.umass.edu/domestic_exchange/* is the resource center for study at other universities in the United States, Canada and Puerto Rico.

The Physics Major in the Job Market

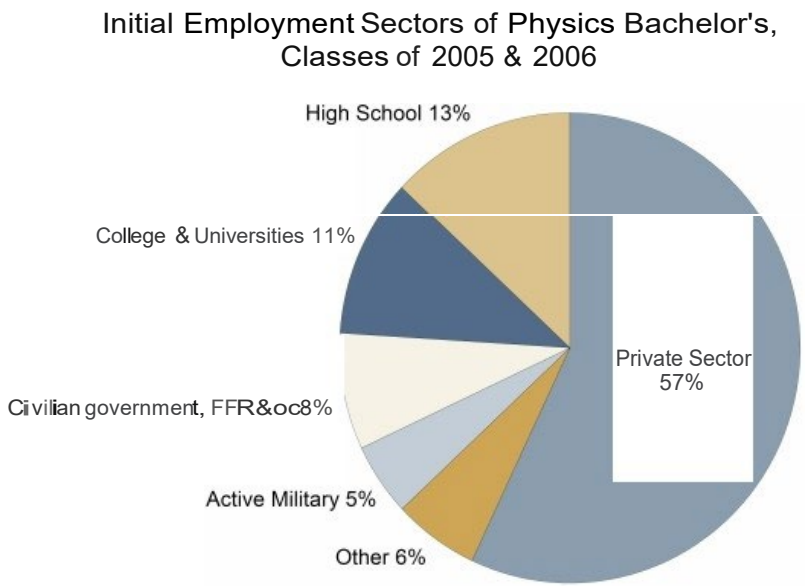
Physics majors are very well trained in broadly transferrable skills:
Our own experience with physics majors is that they are very well trained in the areas of "thinking critically and analytically," Solving Complex Problems," and "Analyzing Numerical and Statistical Information." In the senior survey of 2016, UMass began asking graduating seniors for their self-assessment in these areas. The average responses among physics students were very high, well above the campus averages and nearly the maximum score of 4.

The Physics Dept website has some information and links about careers in physics. Please see https://www.physics.umass.edu/undergraduate

The American Institute of Physics has performed studies that track the careers of Bachelor's degree recipients in physics after graduation. The following graphs are from the AIP website, *www.aip.org/statistics/trends/highlite/emp2/emphigh.htm.*

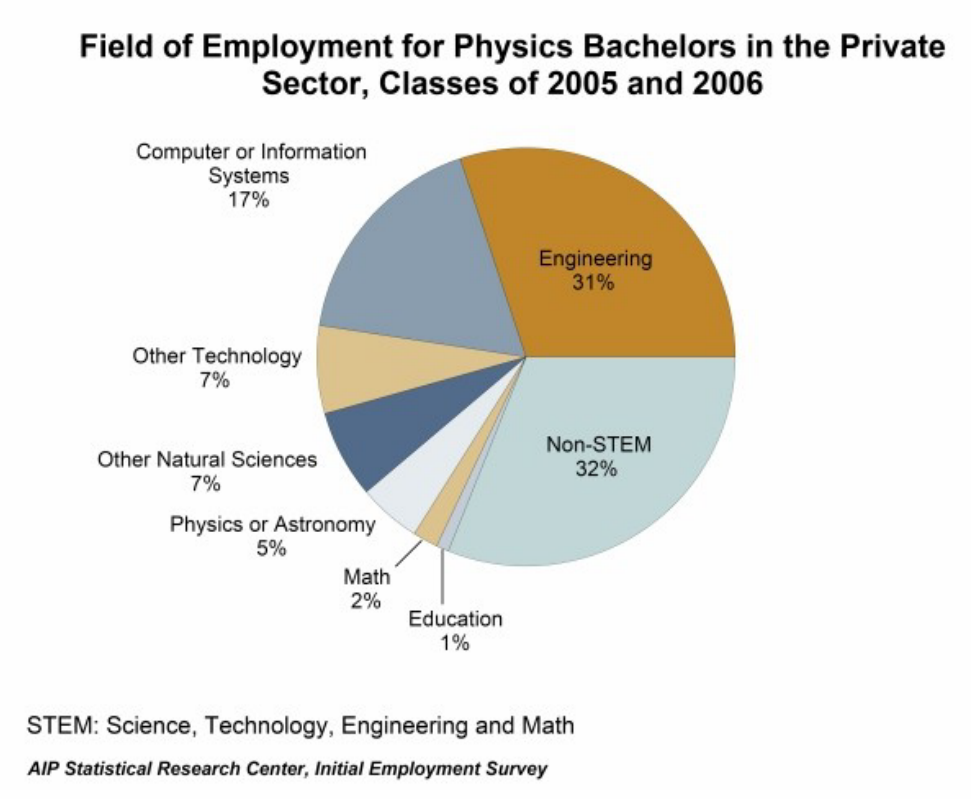


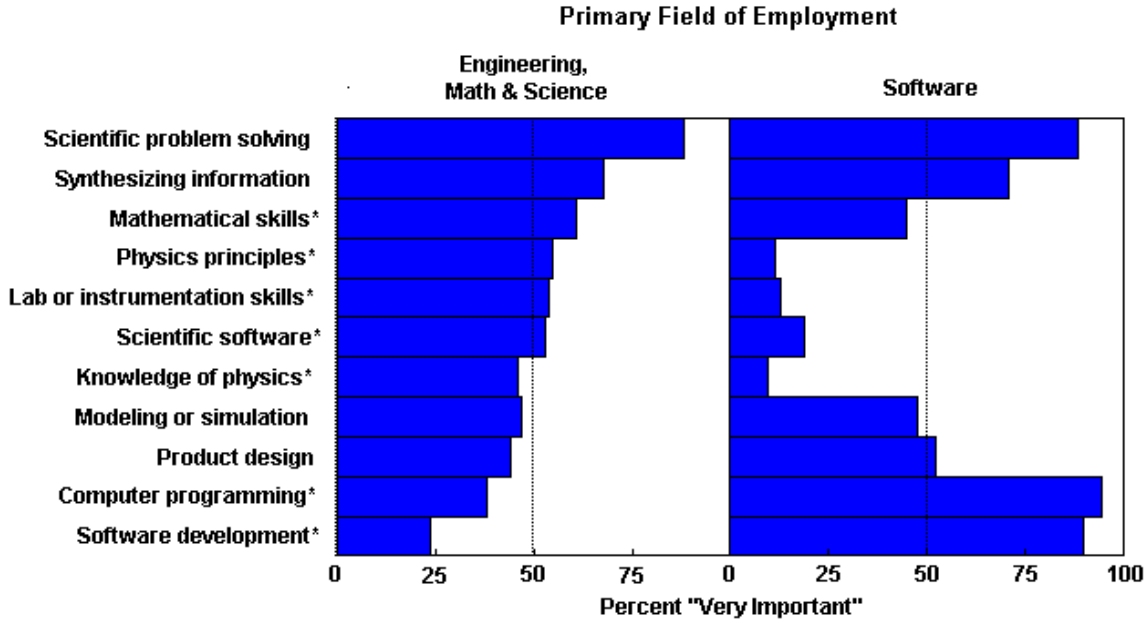
AIP Statistical Research Center, Initial Employment Survey



• FFR&DC: Federally Funded Research & Development Center

AIP Statistical Research Center, Initial Employment Survey





Knowledge and skills rated as important by physics bachelors' degree recipients 5 to 8 years after graduation.

Sept. 2011

Physics Major – Departmental Honors Checklist

Student Name_____ID# _____ Graduation year:____
Academic Advisor's name (in Physics):_____
Formally enrolled in Honors in physics?_____ Enrollment date: _____
Honors Program Director Signature _____ Date: _____

Degree Plans:
Major track: (P,A,G): _____ Minor? _____
Second major? (If so, is physics primary?)_____
Seeking Dept Honors in another department as well?_____
(If yes, note that the Honors requirements, including capstone, must be separately satisfied for <u>both</u> depts.)

Departmental Honors Plans. In addition to the requirements I and II below, students must satisfy the CHC requirements.

I. Two physics Honors courses. One Honors course may be taken at any level, and the other must be at the 300-level or higher. Either requirement can be satisfied by taking a physics Honors Colloquium (*e.g.*, Phys181H, 423H), or by enrolling in Honors independent study *associated with* a physics course. The latter requires that a contract be signed and given to CHC. Please note that a research-based Honors independent study does NOT normally satisfy this requirement. If there are extenuating circumstances, then you must obtain *<u>prior</u>* approval from the Honors Program Director in order for this to count toward the requirement.

<u>Honors Course</u>	**<u>Associated Course</u>**	**<u>Semester/yr</u>**	**<u># credits</u>**	**<u>Grade</u>**	**<u>DH approval</u>**
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

II. Senior Honors (Thesis) Project (*a.k.a.* Capstone), completed under the supervision of a faculty advisor. This is normally a full-year project, divided into two semesters (Phys 499Y in the Fall, 499T in the Spring). Typically, a grade of "Y" is given for satisfactory progress after the Fall semester. At the conclusion of the full project a standard letter grade is submitted, which replaces the "Y" grade.

CHC requires that you complete a "Capstone Completion Form" and obtain advisor's signature.

Project title: _____

Faculty advisor: _____

Course Number(s) and number of credits:

rev. Aug. 2022

Physics Major - Professional Track (BS) Checklist

Student name: _____SPIRE #: _____Advisor name & date: _____

	Course number	Course title or description	# credits	Semester taken	Grade
F1	PHYS 181 (F)	Physics I (Mechanics)	4		
	PHYS 185 (F)	Freshman Colloquium (recommended)	1		
	MATH 131 (F or S)	Calculus I (or take higher class)	4		
	Other	• First-year freshman seminar • GenEd DU or DG	1 4		
S1	PHYS 182 (S)	Physics II (E&M)	4		
	MATH 132 (F or S)	Calculus II (or take higher class)	4		
	PHYS 192M (S)	Intro/Measurmnt *w*/Arduino (recommended)	1		
	Other (optional)	• Independent study (research) • PHYS 281 (S1 or F2 – talk to advisor) • GenEd DU or DG if not already taken	1-3 3 4		
F2	PHYS 287 (F)	Physics III (thermo, waves…)	3		
	PHYS 289 (F)	Physics III Lab	1		
	PHYS 281 (F or S)	Computational Physics	3		
	MATH 233 (F or S)	Calculus III, multivariable (or higher class)	3		
	Other (optional)	• MATH 235 (Linear Alg. - recommended) • TA, PHYS 390T, or indep. study research	3		
S2	PHYS 284 (S)	Modern Physics (relativity & intro QM)	3		
	PHYS 286 (S)	Modern Physics Lab	2		
	PHYS 282 (S)	Techniques of Theoretical Physics	3		
	MATH 331 (F or S)	Ordinary Differential Eqns	3		
	Other (optional)	• MATH 235 (Linar Alg. - recommended) • PHYS 397 (Professional Development) • Apply for summer job/internship by Feb.	3 1 -		
F3	PHYS 421 (F)	Mechanics	4		
	PHYS 424 (F)	Quantum Mechanics	4		
	PHYS 381 (F or S)	Writing in Physics	3		
	Other (optional)	• TA, PHYS 390T, or indep. study research			
S3	PHYS 422 (S)	Electricity and Magnetism	4		
	PHYS 423 (S)	Statistical Physics (stat. mech. & thermo.)	4		
	Other (optional)	• Advanced course (choose from list below) • PHYS 381 if not yet taken • GRE prep (498G) if applying for PhD program • PHYS 397 Professional Development	3 or 4 3 1 1		
F4 & S 4	PHYS 440 (F or S)	Intermed. Lab (ILab) – must email instructors.	4		
	Advanced Course	Choose from the list below	3 or 4		
	Other (optional)	• Research • Applications for jobs or graduate programs	1-3 -		

Advanced course requirement. One course from: PHYS 531 Electronics, 551 Biological Physics, 553 Optics, 556 Nuclei and Elementary Particles, 558 Solid State, 562 Advanced E&M, 564 Advanced Quantum Mechanics, 568 General Relativity, 597Q Quantum Information, ASTRON 337 Optical and IR Astronomy, A338 Radio Astronomy, A451 Astrophysics I, A452 Astrophysics II, or other 500-level physics if approved in advance by UPD. *Students are encouraged to take more than one.*

GenEd info: https://www.umass.edu/gened/sites/default/files/cpg_admitted_students_f2018_rev.pdf

rev. Mar. 2020

Physics Major - Applied Track (BS) Checklist

Student name: _____SPIRE #: _____Advisor name & date: _____

	Course number	Course title or description	# credits	Semester taken	Grade
F1	PHYS 181 (F)	Physics I (Mechanics)	4		
	PHYS 185 (F)	Freshman Colloquium (recommended)	1		
	MATH 131 (F or S)	Calculus I (or take higher class)	4		
	Other	• First-year freshman seminar • GenEd DU or DG	1 4		
S1	PHYS 182 (S)	Physics II (E&M)	4		
	MATH 132 (F or S)	Calculus II (or take higher class)	4		
	PHYS 192M (S)	Intro/Measurmnt *w*/Arduino (recommended)	1		
	Other (optional)	• Independent study (research) • PHYS 281 (S1 or F2 – talk to advisor) • GenEd DU or DG if not already taken	1-3 3 4		
F2	PHYS 287 (F)	Physics III (thermo, waves…)	3		
	PHYS 289 (F)	Physics III Lab	1		
	PHYS 281 (F or S)	Computational Physics	3		
	MATH 233 (F or S)	Calculus III, multivariable (or take higher class)	3		
	Other (optional)	• MATH 235 (Linear Alg. - recommended) • TA, PHYS 390T, or indep. study research	3		
S2	PHYS 284 (S)	Modern Physics (relativity & intro QM)	3		
	PHYS 286 (S)	Modern Physics Lab	2		
	PHYS 282 (S)	Techniques of Theoretical Physics (strongly recommended, esp. if taking P422 or 424)	3		
	Other (optional)	• MATH 235 (Linear Alg.–recomm'd for P424) • PHYS 397 (Professional Development) • Apply for summer job/internship by Feb. • Concentration course	3 1 - 		

Concentration in a Scientific/Technical Field: Minimum 18 credits. Courses must be specified on page 2 of this form and approved by your physics advisor. We recommend seeking advice on course selection from advisors in other departments.

Advanced course requirement. (*a*) At least two of: P421(F) Mechanics, 422(S)** E&M, 423(S) Statistical Phys, or 424(F)** Quantum Mech; AND **(*b*)** at least one of: PHYS 531 Electronics, 551 Biological Physics, 553 Optics, 556 Nuclei and Elementary Particles, 558 Solid State, 562 Advanced E&M, 564 Advanced Quantum Mechanics, 568 General Relativity, ASTRON 337 Optical and IR Astronomy, A338 Radio Astronomy, A451 Astrophysics I, A452 Astrophysics II, or other 500-level physics only if approved in advance by UPD. ***Should not take P422 or 424 without previously taking P282.*

	Course number	Course title or description	# credits	Semester	Grade
F3	PHYS 381 (F or S)	Writing in Physics	3		
	Advanced or Concentration courses				
	Other (optional)	• TA, PHYS 390T, or indep. study research			
S3	Advanced/Concentration		3		
	Other (optional)	• PHYS 381 if not yet taken • PHYS 397 Professional Development • Apply for summer job/internship by Feb.	3 1 -		
F4 & S 4	PHYS 440 (F or S)	Intermed. Lab (ILab) – must email instructors.	4		
	Advanced/Concentration				

GenEd info: https://www.umass.edu/gened/sites/default/files/cpg_admitted_students_f2018_rev.pdf

Plan for your concentration in a scientific/technical field:
In the space below, write the focus or rationale for your 18-credit concentration:

In the table below, list the courses that you plan to take or have already taken. You need a minimum of 18 credits and the plan must be approved by your physics advisor.

Course number	**Course title or description and fit with your concentration**	**# credits**	**Semester taken**	**Grade**

rev. Jan. 2021

Physics Major - General Track (BA) Checklist

Student name: _____SPIRE #: _____Advisor name & date: _____

	Course number	Course title or description	# credits	Semester taken	Grade
F1	PHYS 181 (F)	Physics I (Mechanics)	4		
	PHYS 185 (F)	Freshman Colloquium (recommended)	1		
	MATH 131 (F or S)	Calculus I (or take higher class)	4		
	Other	• First-year freshman seminar • GenEd DU or DG	1 4		
S1	PHYS 182 (S)	Physics II (E&M)	4		
	MATH 132 (F or S)	Calculus II (or take higher class)	4		
	PHYS 192M (S)	Intro/Measurmnt *w*/Arduino (recommended)	1		
	Other (optional)	• Independent study (research) • PHYS 281 (S1 or F2 – talk to advisor) • GenEd DU or DG if not already taken	1-3 3 4		
F2	PHYS 287 (F)	Physics III (thermo, waves…)	3		
	PHYS 289 (F)	Physics III Lab	1		
	PHYS 281 (F or S)	Computational Physics	3		
	MATH 233 (F or S)	Calculus III, multivariable (or take higher class)	3		
	Other (optional)	• MATH 235 (Linear Alg. - recommended) • TA, PHYS 390T, or indep. study research	3		
S2	PHYS 284 (S)	Modern Physics (relativity & intro QM)	3		
	PHYS 286 (S)	Modern Physics Lab	2		
	PHYS 282 (S)	Techniques of Theoretical Physics (optional but strongly recommended, esp. for P422 or 424)	3		
	Other (optional)	• MATH 235 (Linear Alg.–recomm'd for P424) • PHYS 397 (Professional Development) • Apply for summer job/internship by Feb. • Concentration course	3 1 - 		

Concentration in an area of focus: Minimum 18 credits. Courses must be specified on page 2 of this form and approved by your physics advisor. We recommend seeking advice on course selection from advisors in other departments.

Other requirements: PHYS 381 (writing), and PHYS 440, Intermediate lab.

Advanced course requirement: At least one of: P421(F) Mechanics, 422(S)** E&M, 423(S) Statistical Phys, or 424(F)**, PHYS 531 Electronics, 551*** Biological Physics, 553*** Optics, or other 500-level physics only if approved in advance by UPD. ***Should not take P422 or 424 without previously taking P282.*
****500-level courses might have 400-level pre-reqs.*

F3	PHYS 381 (F or S)	Writing in Physics (required)	3		
	Advanced or Concentration courses				
	Other (optional)	• TA, PHYS 390T, or indep. study			
S3	Advanced/Concentration		3		
	Other (optional)	• PHYS 397 Professional Development • Apply for summer job/internship by Feb.	1 -		
F4 & S 4	PHYS 440 (F or S)	Intermed. Lab (ILab) – must email instructors. Required.	4		
	Advanced/Concentration				

Foreign language is required for the BA degree. Check SPIRE to see if this is completed.
GenEd info: https://www.umass.edu/gened/sites/default/files/cpg_admitted_students_f2018_rev.pdf

Plan for your concentration:
In the space below, write the focus or rationale for your 18-credit concentration:

In the table below, list the courses that you plan to take or have already taken. You need a minimum of 18 credits and the plan must be approved by your physics advisor.

Course number	**Course title or description and fit with your concentration**	**# credits**	**Semester taken**	**Grade**