# Advising Notes for Physics Majors

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We put together these notes to help you get the most out of your major, especially when planning your courses. Please look over them carefully, as courses are sequenced, where later courses require prerequisites to be satisfied first. For a full listing of the requirements for the Physics major, see the UC Merced Academic Catalog. You should always feel free to reach out to your academic advisor or the Physics Undergraduate Chair (see Section 6).

## Contents

# 1 Welcome to the Physics Program!

Physics is the study of nature at its most fundamental. Its scope covers everything from the tiniest particles of matter—such as atoms, electrons and quarks—to the structure of the entire universe, encompassing innumerable galaxies and stars. At UC Merced, our areas of research expertise lie in Astrophysics; Quantum Science and Technology (including Condensed Matter Physics and Atomic, Molecular, and Optical Physics); Computational Physics; Biological and Soft Matter Physics; Nanosciences and Condensed Matter Physics; and Solar and Energy Sciences.

## 1.1 Emphasis Tracks

Emphasis tracks build on the physics core to allow students to specialize in a particular physics sub-field or area of focus. It is not required to select an emphasis track and satisfy the Physics B.S. program requirements.Students may also propose and design their own customized emphasis tracks, with the assistance of their faculty advisors. Typically, an emphasis track includes the three upper division physics electives related to the emphasis area and, ideally, a senior thesis in the emphasis area (or the engineering capstone, if appropriate). The current emphasis tracks are:

**Astrophysics** focuses on the physical nature of star, galaxies, and other celestial bodies and the application of physical laws to the interpretation of astronomical observations. Students completing this track are prepared to pursue graduate studies in astronomy or astrophysics.

**Biophysics and Soft Matter** focuses on the application of physics to biological and strongly deformable systems, often at the interface of physics, biology, and chemistry. These systems represent a new frontier in condensed matter and mechanical systems.

**Computation and Data Science** focuses on computational analysis and simulation of physical systems as well as extracting physically meaningful results from large or complex data sets. These techniques allow students to generate and harness vast amounts of scientific data to model and understand the world around us.

**Engineering and Applied Physics** focuses on the application of physics to industrial and engineering processes. As part of this emphasis track, students complete the engineering capstone course to use their physics knowledge in interdisciplinary teams engaged in engineering challenges.

**Mathematical and Computational Physics** focuses on the development of mathematical methods and computational analysis techniques of theoretical physical systems. The mathematical and computer simulation skills developed allow understanding across a wide variety physics domains and application to a range of technical professions beyond physics.

**Quantum Science and Engineering** focuses on the fundamental physics and application of matter-matter or matter-light interactions at the atomic scale. The physical processes observed in these scales and novel new technologies, [[including quantum dots, atomic spectroscopy, and semiconductor devices,]] fundamentally rely on the quantum nature of interactions at the nanoscale.

**High school teaching credential**: Students interested in pursuing a career in physics teaching should complete the Natural Sciences Education (NSED) minor along with the physics major. The NSED minor is designed to prepare UC Merced students for admission to the credential program required to teach high school physics or pursue graduate studies in education. Contact Professor Brian Utter for further information and guidance.

## 1.2 Advising

First-year students receive academic advising through the Bobcat Advising Center. Afterward, you'll be working the physics academic advisor, listed in Section 6 or check Natural Sciences Advising. All physics majors are also assigned a physics faculty advisor. Your *physics faculty advisor* offers you disciplinary expertise on course content; advice for timing courses; and advice for pursuing research, internships, and a physics-related career. Your *academic advisor* offers guidance on meeting all campus, School, and Major requirements for graduation. We recommend students meet with their physics advisor before enrolling in spring courses. Majors are **required** to meet with their physics faculty advisor before enrolling in Fall courses; a hold is placed on your registration for fall course until you meet with your faculty advisor.

When these notes are distributed via the physics majors email list, you should also receive a list of physics faculty advisor assignments. If you cannot locate this, contact the physics undergraduate lead (see Section 6). Check this list to find your physics faculty advisor. All majors participate in research; once you have a research advisor, they typically also become your physics faculty advisor.

### 1.2.1 Timing for Meeting with your Physics Advisor

The course schedule is usually available a month before registration opens. In general, registration for spring classes opens in early November, and early April for fall classes. Contact your physics faculty advisor for a meeting well before registration opens. Faculty schedules are busy, so it's in your best interest to schedule an appointment with as much advance notice as possible. If your physics advisor is on sabbatical, another faculty member will meet with you.

## 1.3 Registering for courses

You should register for your physics courses when your registration window opens. We're one of the smaller majors in the School of Natural Sciences. Although most of our upper-division courses have not reached maximum enrollment, there have been cases where a course has been cancelled due to low enrollment because students assumed there were no consequences for waiting to enroll. For upper-division courses (100's), a minimum of 8 students needs to be enrolled to keep a course from getting cancelled. If a course is conjoined with a graduate course, (cross-listed with 200's, e.g. PHYS 180/280), the minimum enrollment is 4.

### 1.4 Transfer Students

Welcome to UC Merced! We want to make sure that you're getting the most out of your time with our program. In most cases, transfer students have completed the requirements in the first two years an enter with junior standing, but the details depend on your prior course work. Be sure to meet with your Natural Science Advisor and Physics Advisor so we can help make sure you are on track. We're here to help. It is also helpful to think about how to engage in research sooner rather than later.

## 2 Notes by Year

### 2.1 General Considerations

The required number of electives for the major are the minimum needed to graduate. We highly recommend you take as many physics and math courses reasonably able to fit into your schedule. See the tables in Section 3 for information on when classes are offered and when you should take them. Starting research in your second or third year (rather than waiting until fourth year) is an additional way to prepare for graduate school and/or further immerse yourself in the field. If you're pursuing a physics emphasis, the timing of electives is important as they are currently offered every other year. We also encourage all majors to take advantage of summer internship opportunities and clubs such as the Society of Physics Students.

### 2.2 First Year

Enroll in the introductory physics (PHYS 8 and 9) and calculus sequence (MATH 21 and 22) as early as possible. PHYS 8 and 9 are the only physics major courses offered every term, including the summer session. If you are placed into MATH 5, that's no problem; just take that in your fall with a plan to take PHYS 8 and the co-requisite MATH 21 in the spring. The School of Natural Sciences has an early progress policy that states all NatSci majors need to pass their first math and chemistry courses within their first year. If you're deciding between taking chemistry or physics in your first semester, take physics and save chemistry for later!

PHYS 10 (Modern Physics) is only offered in spring terms and requires PHYS 9 as a pre-requisite. Ideally, you should complete the core physics and math courses (PHYS 8, 9, & 10 and MATH 21, 22, 23, & 24) during your first four semesters to stay on track. (For instance, PHYS 10 is a pre-req for PHYS 137 (Quantum I), which is a pre-req for PHYS 138 (Quantum II), 144 (Modern Atomic, Molecular, and Optical Physics), 172 (Quantum Information Science), etc.)
All of our core upper-division courses are only offered in one semester each year; our electives are only offered one semester every *other* year. So timing is important. There have been cases where students have gotten permission to take PHYS 9 and 10 concurrently.

Get to know your fellow physics majors as well as other fans of physics by checking out the student groups, like the Society of Physics Students, Astronomy Club, and Women in Physics (see Section 5.1). Fellow students can give you great advice on classes and navigating your way at UC Merced. Pay attention to emails from the undergrad chair; that's how we make announcements about social

events, exciting seminar speakers, internship opportunities, on-campus job opportunities, etc. For more information contact:

- Astronomy Club: Steven Umbarger (President), Sarah Loebman (Advisor)
- Society of Physics Students: Sheng-Wen Stradleigh (President), Brian Utter (Advisor)
- Women in Physics: Marlen De Jesus (President), Sai Ghosh (Advisor)

### 2.3 Summer Classes

Some students opt to take summer courses in their first couple years to either add flexibility to their schedules or catch up to a typical sequence, though it is certainly not expected. (Students later in their academic careers typically use the summer for paid undergraduate research opportunities.) The physics department routinely offers Phys 8/8L and 9/9L over the summer (currently online courses). Similarly, Chem 2 and Math 5, 21, 22, 23, and 24 are typically offered. You can also take an equivalent class at another institution such as your local community college. Note that summer courses can be more intense as they take place in a shorter period of time than during the semester. Some students also choose to take courses to satisfy General Education requirements to free up their schedules during the academic year.

### 2.4 Second Year

Take PHYS 10 in second year if at all possible. It is currently offered in the spring only. PHYS 10 is a pre-requisite for PHYS 137 (Quantum I) and other classes. Postponing PHYS 10 may set you back a year and increase your time to graduation. By the end of your second year, you should also have completed your core calculus sequence: MATH 21, 22, 23, and 24.

Consider starting research with a faculty member (see Section 5.2.1) or a summer internship (see Section 5.2.4). For those students using PHYS 195/196: Senior Research & Thesis as their capstone, the best theses and research presentations coincide with more time doing research with a faculty member. Doing research with faculty during the academic year and internships at other places during the summer is common in our program. Research with faculty and summer internships are great ways to explore whether a research-oriented career and possibly graduate school would be a good fit for you. It is also a great way to work closely with a faculty member to get recommendation letter for future opportunities. There is an option to complete research for course credit through PHYS 095 (Lower Division Undergraduate Research).

Speaking of careers, it's never too early to prepare for life after UC Merced. The Student Career Center offers workshops, hosts information sessions and panels with employers, career assessments, help on resumes and cover letters, in addition to a number of other resources. The Society of Physics Students offers the Careers Toolbox to help physics majors succeed landing a job in the workforce. Did you know that approximately 35% of physics bachelors graduates work in the engineering field and 27% work in Computer or Information Systems?[1]

[1] https://www.aip.org/statistics

If you love physics and possibly foresee a career in engineering, consider enrolling in ENGR 97: Engineering Service Learning, a 1-2 unit course where you'll join a multi-disciplinary team of students to work with community organizations on real-world problems. Also, consider the Engineering and Applied Physics emphasis.

### 2.5 Third Year

It's time to focus on what electives you want to take over the next two years. Our electives are offered every other year. We're working towards a standard schedule to help you plan, but we're also working to add additional electives (see Section 3).

It's a good time to explore options for after graduation. Starting or continuing research with a faculty member–in anticipation of doing the PHYS 195/196 capstone–aligns with research-oriented careers and preparing for graduate school. Note that Phys 195 can be taken multiple times and it is not necessary to wait until your senior year to enroll. You can do research not only with core physics faculty, but also others doing physics-related research in other departments, e.g. the affiliated faculty of the physics graduate group; see the faculty research listing on our website. Participating in Engineering Service Learning opportunities–in anticipation of the ENGR 193/194 capstone–prepares you to for an engineering-related career track. Don't hesitate to explore both options to find out what truly interests you. Check out the annual Innovate to Grow event from the School of Engineering (end of spring semester) which showcases the work students have done in engineering capstone, if you want to see what that option is like.

Check out the weekly physics colloquium featuring presentations about different topics in physics research by scientists from other places visiting UC Merced, Friday mornings (listed as PHYS 293 in course catalog, but no need to be registered to attend), and PHYS 251 (Introduction to Graduate Research) which features presentations by UC Merced physics faculty about their research aimed at first-year graduate students (again, no need to be registered to attend). Towards the end of the spring semester, one of the colloquium sessions is devoted to PHYS 196 presentations of senior thesis research, so you can see what your peers have been up to and what awaits you next year.

You can also do senior thesis based on work in the summer off-campus at an REU or similar program, with a nominal faculty advisor here to help with final data analysis and thesis-writing. Note that typically senior thesis research is in the topical area of a student's emphasis track, but this is not required, and may not always be possible given the balance of student demand and faculty availability.

Timing for finishing up core courses: If you're considering a PhD program in physics, you should look at taking the Physics GRE in the fall of your fourth year, although many programs have stopped requiring this exam (check ones you may be interested in to be sure); to be well prepared, try to complete your core courses in your third year, as there are some questions on upper-division and elective topics. The more physics you take in your third year, the better prepared you will be!

Research: Get started engaging in research with faculty *early*. We strongly recommend starting by the summer between your third and fourth years. **Before the end of your third year**, make

sure that you have found a faculty member with whom you can complete your senior thesis if using PHYS 195/196 as your capstone (even if you plan on starting research in the fall of your fourth year). For graduate school applications, research experience is very helpful so you can discuss it in your statement of purpose, show your accomplishments, and also get a better idea of whether graduate research is how you want to spend the next 5-6 years, and what subfield(s) of physics you are interested in. *Note that physics graduate school is entirely paid for by the graduate school — you will get paid in addition to getting to getting an advanced degree!* (You won't get rich in grad school, but you shouldn't have debt afterwards either.)

Timing for electives: Especially if you have an emphasis, pay attention to the timing of electives that satisfy it as well as necessary pre-requisites. Our schedule is designed to offer every elective every two years. Explore your interests via electives. For PhD applications, it is not essential to have done research in the same subfield in which you would like to pursue your PhD, but it certainly helps, and it is important to help get an idea of your interests.

### 2.6 Fourth Year

The capstone experience is a year-long sequence typically in the fourth year. Typically, it is satisfied with PHYS 195/196: Senior Research & Thesis. Students can satisfy the capstone experience with ENGR 193/194: Engineering Capstone Design I/II. If your post-UC Merced plans include graduate school, we recommend PHYS 195/196. If you are more interested in an engineering career, we recommend the Engineering Capstone Design.

*PHYS 195/196: Senior Research & Thesis.* The major requirement is to take two credits of PHYS 195 (taken for a letter grade) and then enroll in the two-credit PHYS 196 course. PHYS 195 consists of doing research with your faculty advisor. PHYS 196 is research with your advisor but also a weekly one-hour class, guiding you through the preparation of your written thesis and presentation. It culminates in a presentation to the department during the weekly colloquium at the end of the spring semester. Most students take PHYS 195 in the fall and PHYS 196 in the spring of their senior year, though it is possible to enroll in PHYS 195 multiple semesters or for a variable number of credits (with about 3 hour work per credit hour the expectation). There's more information about finding a research mentor in Section 5.2.1. Note that PHYS 195 is a pre-requisite for PHYS 196.

*ENGR 193/194: Engineering Capstone Design I/II.* The Engineering Capstone is a 5-unit sequence. Students work in multidisciplinary teams completing design projects presented by industrial partners. Teams focus on planning, concept, and system design. Note that Phys 160 is needed as a pre-requisite to ENGR 193.

Note that it is also possible to take graduate courses with permission of instructor, if you are well-prepared in the foundational material, usually one of the four core classes: PHYS 205, 210, 212, or 237. Why would you want to, you might ask? It allows you to go deeper into a particular subject and prepare you for graduate-level coursework, if that's in your future — it also looks nice on your transcript when applying for grad school. Interested students should fill out the online form available at the Registrar's Office forms page.

### 2.7 Beyond the Fourth Year

There are a number of reasons why students may graduate after their fourth year. Please work with your academic and physics advisors to plan for graduating. It may also be an opportunity for you to take additional electives, pick up a minor, or experience an additional summer internship.

### 2.8 After UC Merced

Take the next step by researching graduate programs, professional programs, and/or job opportunities as soon as you begin taking upper-division course. Graduate applications are typically due in late fall. Take a look at some of the information and advice provided from our own PhD program. You are welcome to apply to our own program, but also the advice there is generally true for other US physics PhD programs too. Career Services has a number of resources, including a STEM Career Specialist, to help prepare for the job market. Take a look at our alumni listing to see what your peers have been going on to do.

## 3 Physics Courses: Timing and Additional Information

Table 1 shows when our courses are offered, projected into the coming years. Since we are a small but growing major, our classes are not offered every term. Required (aka Core) courses are offered every year. Electives are generally offered once every two years. We're working to offer a reliable schedule of electives so that students can better plan when to take electives, especially those that are needed for an emphasis.

**PHYS 8-9-10:** The intro sequence courses are often pre-requisites for later courses. It is possible to take each of these courses over the summer if necessary to stay on track. You can use assist.org to determine which courses will transfer to UC Merced. Note that summer courses are typically fast-paced given the shorter duration, so consider which courses (including potential General Education options) would be most manageable/helpful in your course planning.

**Pre-requisites:** Pre-requisites are there to support your success in the course. However, if not taking a particular course will impact your course plan or ability to complete an emphasis or graduate on time, you can discuss this with your advisor and/or the faculty member teaching the course. It may be that it's possible to be successful without the pre-req with additional guidance from the instructor. Note also that any course listed as a **co-requisite** can also be taken before the class you're interested in. For instance, PHYS 137 is a co-req for PHYS 141, but not vice-versa, so it is possible to take PHYS 137 first and still enroll in PHYS 141 later.

**Minimum enrollment:** It's important to enroll in your physics courses early. For lower-division courses (course numbers less than 100), 12 students must be enrolled for a course to be offered. For an upper-division course, the minimum number is 8. For a course conjoined with a graduate course (e.g. PHYS 141/241), 4 students must be enrolled. There are cases where a course that does not meet minimum enrollment may still be offered. For example, PHYS 196: Senior Thesis is a core course; it is offered every fall and spring term. An elective necessary for an emphasis requirement for students to graduate may still be offered. Electives that are not required for an emphasis track are likely to be cancelled if enrolled is too low.

**Computer Science Requirement:** The major includes a computer science requirement, satisfied by CSE 019, CSE 022, DSC 011, ME 021, or BIOE 021. The different courses provide flexibility in scheduling and any is good to take to satisfy the requirement. However, the physics department has opted to use Python as a default programming language in the curriculum when possible. BIOE 21and CSE 022 use Python, ME 021 introduced both Python and Matlab, and DSC 011 introduces Python as one of a variety of languages introduced.

**PHYS 10 labs:** The labs occur approximately every other week and last 6 hours. This allows us to offer multiple lab sessions without the previous section interfering with a following section's lab setups.

**PHYS 108: Thermal and Statistical Physics Core:** Multivariable calculus (MATH 24) is strongly recommended as a pre- or co-requisite for PHYS 108. It is possible to take MATH 24 before MATH 23 in your sophomore year.

**PHYS 195 & 196: Senior Research & Thesis:** To enroll in either PHYS 195 or PHYS 196, fill out an Independent Study Form.

- If you are doing research with a faculty member outside of Physics, contact the Physics Undergraduate Chair so that your advisor can have a section listed in the course and you get the proper credit for the course. (This often comes up with students doing a double-major and/or a custom emphasis.)
- Note that PHYS 195 is a pre-requisite to enroll in PHYS 196. The Physics department is no longer approving exceptions to co-enroll in PHYS 195 and 196.
- If you make arrangements with your research advisor to take PHYS 196 during the summer there is no seminar component; it is recommended you take PHYS 196 during the fall or spring semester.

Table 1: *Tentative* Schedule of Physics Courses. Core courses are offered every year and marked with an 'X' to indicate the term offered. Also shown are recommendations for the year to take the course–based on a 4-year plan. Electives are offered every other year in the same term. The emphasis is indicated, if applicable. Pre = Pre-requisite courses, Co = co-requisite courses, and Rec = courses recommended as prerequisites. P=PHYS, M = MATH, C = CHEM

| **Core Courses** | **Pre, (Co), [Rec]** | **F** | **S** | **Year** | **Notes** |
|---|---|---|---|---|---|
| P008, 8L: Intro I | (M21) | X | X | 1st | Offered in summer also |
| P009, 9L: Intro II | P8, (M22) | X | X | 1st | Offered in summer also |
| P010: Intro III | P9[1] | | X | 2nd | |
| P105: Mechanics | P8, (M23, M24) | | X | 2nd | |
| P108: Thermal & Statistical Phys | P9, [M24] | X | | 2nd[2] or 3rd | |
| P110: E&M I | P9, M23 | X | | 3rd or 4th | |
| P115: E&M II | P110 | | X | 3rd or 4th | |
| P126: Sp. Relativity mini | P9, [P110] | | X | 2nd | |
| P137: Quantum I | P10, M23, M24 | X | | 3rd or 4th | |
| P138: Quantum II (mini) | P137 | | X | 3rd or 4th | |
| P160: Modern Lab | P10 | | X | 3rd | |
| P195: Ugrad Research | 3rd/4th year student | X | X | 3rd or 4th | or ENGR 193 |
| P196: Thesis Research | P195 | X | X | 4th | or ENGR 194 |
| **Electives** | | **F** | **S** | **Year** | **Emphasis** |
| P095: Ugrad Research | 1st/2nd year student | X | X | | |
| P104: Biophysics | P8, P9 | F24, F26 | | Even years | Bio/soft |
| P109: Soft Matter | P108 | | S23, S25 | Odd years | Bio/soft, Eng/appl |
| P116: Math. Methods | P9, M23, M24 | F23, F25 | | Odd years | Astro, Math/comp |
| P121: Cosmology | (M23) | | S24, S26 | Even years | Astro |
| P123: Stellar Struct | P8 | F24, F26 | | Even years | Astro |
| P127: Machine Learning Astro | P9, M32 | F23, F25 | | Odd years | Astro, Comp/data, Eng/appl, Math/comp |
| P141: Condensed Matter | (P137) | F23, F25 | | Odd years | QST, Eng/appl |
| P144: Modern AMO | P137 | | S24, S26 | Odd years | QST |
| P148: Modern Optics | P9, M23, M24 | F24, F26 | | Even years | QST |
| P172: Quantum Info. Sci. | P137 | F24, F26 | | Even years | QST, Eng/appl |
| P180: Non-Linear Dyn. | P8, M23, M24, [P105] | | S23, S25 | Odd years | Astro, Math/comp |
| P181: Computational Phys. | P10, CS, M23, M24, [P116] | F24, F26 | | Even years | All emphases |
| P192: Special Topics | P9 | varies | varies | varies | Topic varies |

[1] It is possible to take PHYS 9 and 10 concurrently with permission, but MATH 22 should be completed already.

[2] Preferred.

Table 2: *Tentative* Schedule of Courses outside of Physics. Also shown are recommendations for the year to take the course–based on a 4-year plan. Pre = Pre-requisite courses, Co = co-requisite courses, and Rec = courses recommended as prerequisites. P=PHYS, M = MATH, C = CHEM

| **Core Courses** | **Pre, (Co)** | **F** | **S** | **Year** | **Notes** |
|---|---|---|---|---|---|
| C002: General Chemistry I | Placement exam or C1 | X | X | 1st | Offered in summer also |
| M005: Preparatory Calculus | | X | X | 1st | Offered in summer also |
| M021: Calculus I | Placement exam or M5 | X | X | 1st | Offered in summer also |
| M022: Calculus II | M21 | X | X | 2nd | Offered in summer also |
| M023: Vector Calculus | M22 | X | X | 2nd | Offered in summer also |
| M024: Linear Algebra and Differential Eqs. | M22 | X | X | 2nd | Offered in summer also |
| M032: Probability and Statistics | M22 | X | X | 3rd | Offered in summer also |

Table 3: Elective options for emphasis tracks

| **Emphasis track** | **Electives** |
|---|---|
| Astrophysics | **Required:** PHYS 121: Cosmology and PHYS 123: Galactic Structure and Interstellar Medium<br>**Complete at least one:** PHYS 116: Mathematical Methods, PHYS 127: Machine Learning and Statistics for Physics and Astronomy, PHYS 180: Nonlinear Dynamics, PHYS 181: Computational Physics ,MATH 180: Applied Statistics and Machine Learning. |
| Biophysics and Soft Matter | **Required:** PHYS 104: Biophysics and PHYS 109: Soft Matter Physics<br>**Recommended:** BIO 011: Introduction to Molecular Biology<br>**Complete at least one:** PHYS 181: Computational Physics, BIO 101: Biochemistry I, BIO 106: Introduction to Molecular and Cell Biology, BIO 110: The Cell, BIO 140: Genetics, BIO 141: Evolution, BIO 145: Introduction to Population and Community Ecology, BIO 161: Human Physiology, BIO 180: Mathematical Modeling for Biology, BIO 184: Python Programming for Life Sciences, BIOE 102: Biosensors, BIOE 104: Biotransport Phenomena, BIOE 113: Bioinstrumentation, MSE 126: Nanodevice Fabrication: Bridging Research and Education, MSE 109: Materials Thermodynamics, MSE 113: Materials Characterization, MSE 118: Introduction to Nanotechnology and Nanoscience. |
| Engineering and Applied Physics | **Complete in place of PHYS 195/196: Senior Thesis:** ENGR 193: Engineering Capstone Design I, ENGR 194: Engineering Capstone Design II Units: 3<br>**Complete at least 12 units:** PHYS 109: Soft Matter Physics, PHYS 127: Machine Learning and Statistics for Physics and Astronomy, PHYS 141: Condensed Matter Physics, PHYS 172: Quantum Information Science, PHYS 181: Computational Physics, ENGR 120: Fluid Mechanics, ENGR 155: Engineering Economic Analysis, ENGR 170: Introduction to Electron Microscopy, ENGR 180: Spatial Analysis and Modeling, BIOE 102: Biosensors, BIOE 104: Biotransport Phenomena, BIOE 113: Bioinstrumentation, ME 135: Finite Element Analysis, ME 137: Computer Aided Engineering, ME 142: Mechatronics, MSE 109: Materials Thermodynamics, MSE 110: Solid State Materials, MSE 113: Materials Characterization, MSE 118: Introduction to Nanotechnology and Nanoscience, MSE 126: Nanodevice Fabrication: Bridging Research and Education. |
| Computation and Data Science | Two upper-division courses |
| Mathematical and Computational Physics | **Required:** PHYS 116: Mathematical Methods and PHYS 181: Computational Physics<br>**Complete at least one:** PHYS 127: Machine Learning and Statistics for Physics and Astronomy, PHYS 180: Nonlinear Dynamics, MATH 122: Complex Variables and Applications, MATH 125: Intermediate Differential Equations, MATH 126: Partial Differential Equations, MATH 130: Numerical Analysis, MATH 132: Numerical Methods for Differential Equations, MATH 141: Linear Analysis I, MATH 150: Mathematical Modeling, MATH 180: Applied Statistics and Machine Learning, MATH 181: Stochastic Processes. |
| Quantum Science and Engineering | **Complete at least three of the following:** PHYS 141: Condensed Matter Physics, PHYS 144: Modern Atomic, Molecular, and Optical Physics, PHYS 148: Modern Optics, PHYS 172: Quantum Information Science, PHYS 181: Computational Physics. |
| High school teaching | Complete Natural Sciences Education (NSED) minor[1] |

[1] See Professor Utter for information and guidance.

# 4 Administrative Considerations

**Hold on Registration** To ensure you meet with your physics faculty advisor before enrolling for Fall courses, in Spring semester there is a hold placed on your registration. This is lifted only after meeting with your physics advisor. Your physics faculty advisor fills out an online form and the registration hold is lifted within one business day.

**General Catalog** A student is subject to the policies in the General Catalog in effect when they initially enroll. Through that link, you can access the current and archived copies of the Catalog. Students may also petition to adopt the policies in a newer catalog. *If possible, we recommend that students adopt changes made to the physics program.* Contact your physics and academic advisor if you have questions about adopting changes.

**Requirements for the Physics Major** The requirements for the major as well as the various emphasis tracks are listed in the General Catalog. Sample plans of study are attached at the end of these advising notes.

**Early Progress Policy** Any Natural Sciences major must pass the first course in the Math and Chemistry sequences–MATH 005 (or MATH 011 or MATH 021) and CHEM 001 (or CHEM 002)–prior to the start of their third regular (Fall/Spring) semester. Any student failing to do so will be moved to undeclared status. Please see Natural Sciences Advising or your academic advisor if you have questions. **Understand that this does NOT specify that you must take Chemistry your first semester at UC Merced. If you're deciding between Physics 8 and Chemistry for the fall term, we advise taking Physics 8 in the fall and saving Chemistry for the spring term.**

**Normal Progress to Degree** UC Merced undergraduate degree programs are designed to be completed in eight semesters or four academic years. (Summer terms are not included in the semester count.) To meet the normal progress requirement, undergraduate students are expected to enroll in and pass an average of 15 units per semester, completing the 120 units necessary for graduation in four years. An extension of enrollment beyond nine semesters requires the approval of the student's School.

# 5 Beyond Classes

## 5.1 Student Groups

The Society of Physics Students (SPS) Chapter #0922 holds weekly meetings, study sessions, organizes outreach events, and works on various projects throughout the academic year. Find more information on the physics website about SPS. There is also an active Astronomy Club and a Women in Physics group. We encourage all majors to check it out and meet fellow students also interested in physics. Even better, help contribute to the success of these groups by eventually taking on a leadership role!

## 5.2 Research

Physics is more than taking classes. Research allows you to explore a specialization in detail. We encourage students to engage in research before their senior year and there are multiple options. Below are the most common pathways our majors have used to get undergraduate research experience. There is also some information on our webpage. Dr. Utter is also a point of contact for questions about getting involved in undergraduate research.

### 5.2.1 Research with Physics Faculty

Doing research with a faculty member is a great opportunity for all our majors, not just those choosing the PHYS 195/196 capstone. To find a faculty member with whom to work, we recommend looking at the list of faculty members by research area with their lab websites linked, to learn about their research areas. You are also welcome to sit in on *PHYS 251: Introduction to Graduate Research*; though this is a graduate course, it's goal is to expose students to research being done in the department. (Feel free to reach out to the instructor to find out which faculty members are presenting when if you want to learn more about specific research groups.) It is also possible to complete your physics research with Affiliate Faculty members, who are professors in other departments who work on research areas strongly overlapping with physics; follow this link for a list of Affiliate Faculty.

After identifying a couple of faculty members whose research interest you, introduce yourself in an email. Ask about research opportunities within their lab. You can also ask if they have other undergraduates doing research in the lab to get a peer's perspective on the experience. You can ask to attend a group meeting and/or visit the lab to find out of it would be a good fit. Each lab has its own culture. Some things to consider include whether you're interested in computational/theoretical or experimental research. Would you be working under the supervision of the professor, postdoctoral researcher, or a graduate student? What time commitment is needed to make progress on the project? (Does that fit with your course load and schedule?) What projects are available? What kind of tasks would you do? What course knowledge or skills are needed?

If you are going to be doing research for credit (PHYS 095 or 195), you will need to submit an Independent Study Form. Research courses do not show up on the schedule. Note that you don't need to sign up for research credits in order to do research with a faculty member; contact them anytime throughout the year.

Typically funding is available to pay you for summer research from the faculty's research grants. Occasionally there may be funding available for academic-year research as well, including through the Center for Cellular and Biomolecular Machines (CCBM)'s undergraduate research fellowship program. There are also summer opportunities through CCBM and UROC.

### 5.2.2 Conferences

There are a variety of conferences that you can attend, in order to present a poster or maybe even a talk about your research, learn about research, network with others, talk to graduate school representatives, find a peer support group, learn about careers, and engage in professional development.

Funding to attend can be available from the physics department, the faculty research group you are working with, or the conference itself. If a local conference costs $100 for instance, the department can easily cover that. Reach out to the Physics Chair or Undergraduate Chair for more information.

These are some conferences specifically aimed at undergraduates which UC Merced students have attended recently:

- The Conferences for Undergraduate Women and Gender Minorities in Physics (CU*iP) is held annually in January somewhere in northern California along with other sites around the country. UC Merced hosted in 2023.
- The American Physical Society Far West Section meeting is held annually in the fall, somewhere in CA, NV, or HI. UC Merced hosted in 2017.
- The Physics Congress (PhysCon) is held every two years somewhere in the country around November; it is specifically for undergraduates and is related to the Society of Physics Students (SPS).
- The National Diversity in STEM conference is held annually by the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) somewhere in the country around the end of October. Also there is a SACNAS chapter on campus.
- The National Society of Hispanic Physicists (NSHP) conference is held annually.
- The National Society of Black Physicists (NSBP) conference is held annually.

If you have some research results to show, you could also attend one of the annual national research conferences that our faculty and graduate students often attend such as the American Physical Society March Meeting or American Astronomical Society (January).

### 5.2.3 UROC

The Undergraduate Research Opportunities Center (UROC) is a great resource on campus and also runs the Summer Undergraduate Research Institute (SURI). UROC offers information sessions to help you submit applications for summer internships. It also posts UC Merced and UC-specific internships. For example, the UC LEADS program lasts 2 years, with one summer doing research at UC Merced, and the other summer doing research on another UC campus. There is also the California Alliance for Minority Participation (CAMP). Physics majors have participated in both of these. Most programs advertised or organized by UROC have early spring deadlines.

### 5.2.4 Summer Internships

Summer internships are mostly *paid* internships and often include professional development activities. *Note that many of these deadlines occur in January and February, so you should be starting your search in December/January.* For especially competitive programs, it is wise to submit your complete application well before the deadline.

Check out the CCBM research opportunities related to biophysics and soft-matter physics.

Internships at other institutions are a great way to explore research areas we don't currently have at UC Merced (e.g. particle physics or nuclear physics), potential graduate programs, and/or potential career paths. The National Science Foundation (NSF) funds Research Experiences for Undergraduates (REU) at various universities. If you're considering graduate school and are curious about a particular school, see if they have an REU program.

Use the Physics Today Jobs site to search for internships. SACNAS, the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science, also lists internships. Pathways to Science is another useful search engine for summer programs.

The Department of Energy (DOE) offers internships at 17 national labs (including nearby Lawrence Berkeley, Lawrence Livermore, and Sandia National Laboratories – there is a branch of Sandia in Livermore as well as New Mexico) and facilities through their SULI program. NASA internships are highly competitive and have early deadline.

Caltech's Jet Propulsion Laboratory (JPL) has numerous opportunities. Federal Agencies, such as the National Institute of Science and Technology (NIST), will often list internships here.

We also have some special summer opportunities through partnerships between UC Merced and other institutions. There is a summer research program through the Consortium for High Energy Density Science (CfHEDS) which arranges summer research with Lawrence Livermore about high-power lasers and plasma physics as well as development of resources for physics labs with smartphones. Prof. Strubbe is the contact person.

Research at Lawrence Livermore or Los Alamos National Laboratories can be arranged and funded under the Minority Serving Institutions Internship Program (MSIIP), with annual deadline in late October.

# 6 Contact Information

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